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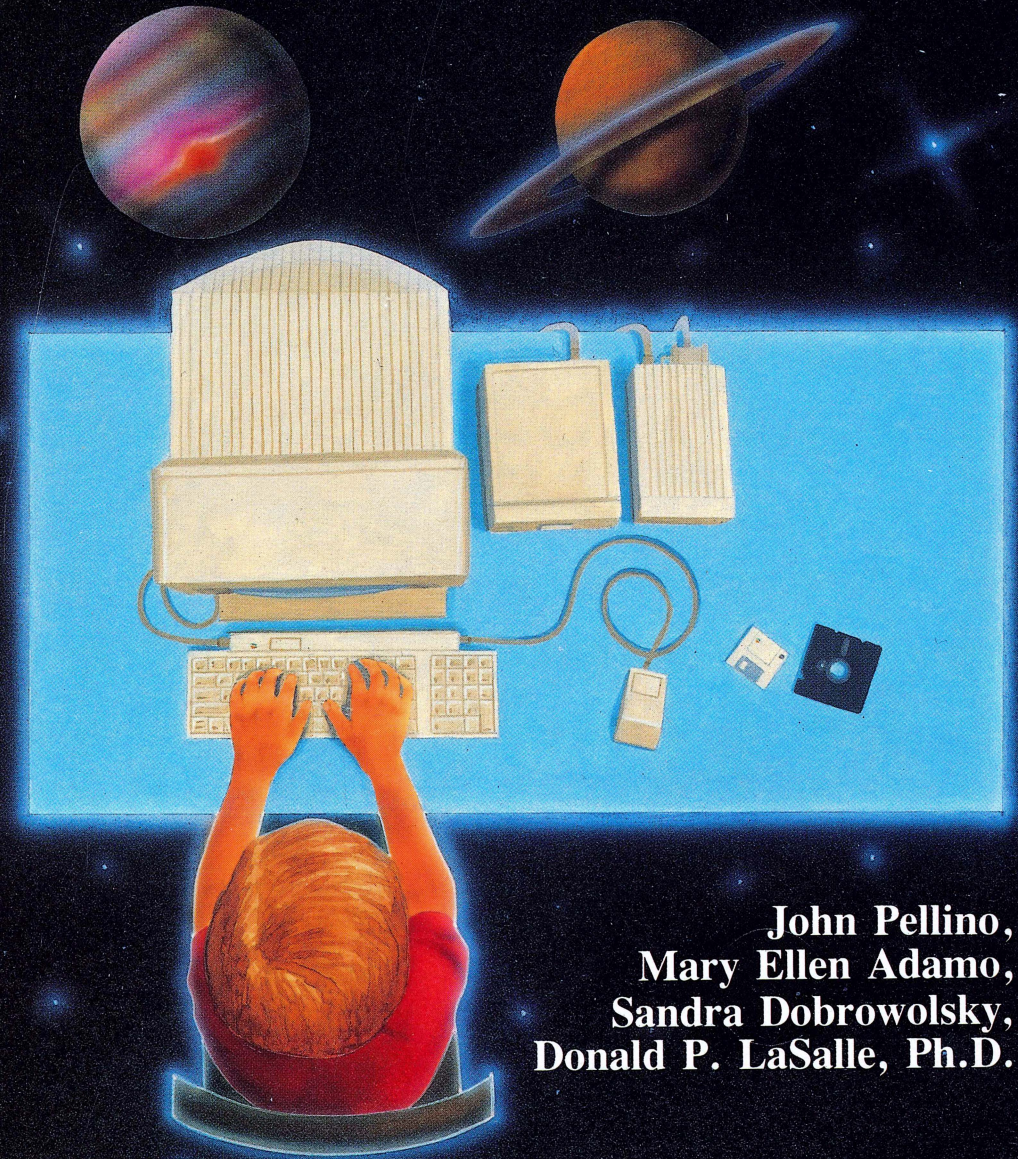
Discovering Science on Your APPLE® II, II+, IIe, IIc, and IIGS®



John Pellino,
Mary Ellen Adamo,
Sandra Dobrowolsky,
Donald P. LaSalle, Ph.D.

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And finally to our families for their support in the midst of long nights and weekends and for keeping lots of dinners warm.

Thank you one and all.

For Kids Only

You're about to embark on a new adventure. Like all adventures, the fun lies in discovery — finding new things, seeing new places, meeting new people. Using this book, you'll measure the size of the earth, tour the solar system, forecast weather, identify rocks, and analyze experiments. You'll visit all nine planets, and "rub shoulders" with Newton, Einstein, Galileo, Darwin, Kepler, and supersonic bees!

All of this fun has the proper name of "science" — the process of doing your best with your brain to find out about the world around you. We hope that by the time you get through this book, you will see why scientists get so excited about their work — the intrigue of discovery and investigation, the satisfaction of working out solutions, and the breathtaking view you have while standing "on the shoulders of giants."

We said that this is an adventure, a journey of sorts. Your Apple is your vehicle, this book is a map, and your imagination is your fuel, as well as your only limit. Go through your adventures as fast as you want. You can always backtrack, and spend as much time as you like on any one of them. May all your adventures be happy ones!

For Parents Only

This book was written to give students a taste of science while they become experienced in the use of a computer. We hope that it helps make these experiences both personally enjoyable and educationally productive.

We have drawn on our combined expertise in the fields of science and computers, and, when necessary, called upon master teachers and scientists to aid in the preparation of the text. This book represents over three decades of combined experience in education, science, and computers.

Talcott Mountain Science Center is dedicated to bringing science and its wonders to all students, by whatever means needed. In recent years, this has meant not only training students and teachers in the classroom, but also sharing our expertise by means of television, computer software, and books such as this one.

As educators, our guidelines include some key concepts: individualized instruction and hands-on involvement. We feel that computer books can be excellent in this regard. Students learn one-on-one with the computer as a guide, and might, as time goes by, involve friends, both around the block and around the world, to share in their adventures. Most of the programs contain experiments that have the student doing science, instead of simply reading about it or watching it done by someone else.

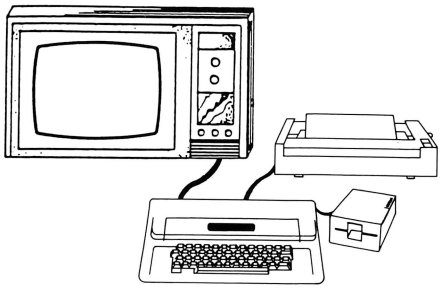
An ancient Chinese proverb sums this up quite nicely:

I hear, and I forget.
I see, and I remember.
I DO, and I understand.

You're invited on these adventures, too. If you ask politely, we're sure your youngster will let you "tag along." (If not, tell them that you have our permission.)

Our best wishes for your child's successful adventures in science.

1



Adventure Preparations

All of the programs in this book were written for the Apple II computer using Applesoft Basic. This is the language that came with your machine. Once your machine is up and running, you need only type in the program at the end of each adventure section, read the description of the adventure for some background, and run the program.

Most of the programs have some experiments for you and your friends to do. Others will simply ask you some questions. Many of the programs can be modified to run the way you'd like them to, to do different things, or to improve them.

To change the programs, you need to be able to program in Applesoft Basic. You might have learned some Basic language at school or on a friend's computer. Chances are, if you can write in any Basic, you can write in Applesoft Basic, because they have a lot in common. If your Basic skills need some polishing, check out the manual that came with your Apple, or stop by your local library or bookstore.

GETTING STARTED

Your Apple comes with a terminal, disk drive, and a monitor. You will also need diskettes. Your Apple also comes with a System Disk that you will use to prepare the blank diskettes you buy at the computer store for use on your computer.

The diskettes are delicate. They use the same medium (magnetic coating) as audio tapes, but you must take better care of them. All magnetic media gets damaged in some way due to handling. This is no big deal for your musical tapes, because your ear is very tolerant, and a speck of static is small compared to the size of musical

notes. But the same speck on an Apple disk can be disastrous. Apple's "ears" are much more critical than yours, and one speck can wipe out dozens of data notes, making the whole program unreadable.

The disk contains concentric circles and sectors that make addresses for the Apple to read. Here are some simple rules for taking care of your disks:

☐ Don't touch the shiny parts (exposed slits). The best way to protect your disks is to keep them in their protective sleeves when you are not using them.
☐ Don't shove them into the disk drive. Don't bend them, drop things on them, hold them together with paper clips, or spill soda on them, or they will lose their memory.
☐ Don't boil or freeze them. Keep them between 50 and 125 degrees Fahrenheit. If it is too hot or too cold, disks can lose their memory.
☐ Make a back-up. After you have spent the time to type in all of the programs, copy them onto another disk. You have spent a lot of time. You would not want that time wasted.

Prepare Your Own Disk

The following steps get your disk ready to type in your adventures. This is often called *initializing* a disk. Some systems call it *formatting.* It involves the disk operating system called DOS and the concentric circles and sectors that allow your Apple to read the disk. Once it is done, the disk is an Apple disk and will not work on other machines. If you have an Apple II, II+, or IIe, follow these steps:

1. Put the system disk into the disk drive. Turn on the computer. (If the monitor is not on, you may turn it on.)
2. Take the system disk out and put in the new disk. Type NEW and hit the RETURN key.
3. You will create a greeting program that will appear when you *boot* the machine. (Booting is when you turn on the machine with a disk in the disk drive. The computer and the disk drive can "talk" to each other.) The greeting program will be in Applesoft Basic, and be called the HELLO program. Type this program as it appears, typing your own name where it says YOUR NAME:

```
10 HOME
20 PRINT "YOUR NAME"
```

4. Now you will type the command that will initialize your disk. You only use this command **once.** If you misuse this command at any other time, you will wipe out any data that is on your disk. **BE CAREFUL!** To execute the command, type INIT HELLO and hit RETURN.

When the light on the disk drive goes off, your job is complete. Did you notice the unusual noise that the disk drive makes when initializing or formatting? This is the only time you should hear it.

Now you can turn off the computer and put your disk into the disk drive, turn on the computer and boot the system with your disk.

FOR APPLE IIc USERS ONLY, follow these steps to initialize a disk:

1. Put the Apple IIc System Utilities disk in the drive and turn on the machine.
2. Follow the directions by choosing option #6, FORMAT A DISK.
3. It asks you if you want the *built-in* or *external* drive (the disk drive in the machine, or the extra drive).
4. You may use PRODOS or DOS 3.3; either will do.
5. You can put your name on the disk by deleting up to the slash and then typing your name.
6. Hit RETURN and you will receive the message FORMATTING IS DONE.

To begin an adventure, type NEW. Then, enter the program as it appears in the book.

FOR APPLE IIGS USERS ONLY, refer to your user's guide and format using DeskTop.

EDITING PROGRAMS

To change a line that you have typed in, use the following procedure:

1. List that line (for example, LIST 480 will put line 480 on the screen for you).
2. On the IIe and IIc you can move the cursor (that blinking prompt) by moving the arrow keys.
3. You can change a line by simply typing it over again (be sure to include the line number).

SAVING PROGRAMS

When a program works the way you want it to, you can save it on a disk. The disks have a large amount of storage available. All the programs in this book will easily fit on one side of a disk. The following steps will save a program onto a disk:

1. Check your program to see if it runs correctly.
2. Type SAVE and give the program a name. For example, ORBPER would be good for Orbital Periods. ORB.PERIODS would be fine too. You can decide the name that you want.
3. When you look at the list of the programs on the disk (by typing CATALOG), you will see the names and some letters and numbers:

```
A  002  ORB.PERIOD
A  008  WEIGHT
```

The A stands for Applesoft Basic, and the numbers correspond to sectors.

LOADING PROGRAMS

To copy a program from the disk into memory, type LOAD and the name of the program. When the prompt appears on the screen and the disk drive light goes off, you can type RUN to begin the program, or LIST to view the program lines. Be sure that the capslock switch on the IIe and IIc is down when entering a program.

RULES OF SYNTAX

Spaces seem to be important at times and not at others. A FOR NEXT loop will not work if you forget spaces. Try to use the spacing in the text at all times.

NUMBERS ON THE SCREEN

Throughout the programs, you will see numbers converted to a certain number of decimal places by using a statement like this:

```
X=INT(X*10^3+.5)/INT(10^3+.5)
```

This rounds numbers off to the number of places you desire, as long as the number of places that you desire is where the "3" is in our example. This is needed because the Apple calculates out to nine decimal places without being asked. Sometimes this can come in handy, but most of the time it's distracting. We've rounded off the places that you won't need.

SCREEN FORMATTING

Apple II computers have 40 characters in two printing zones on their screens. The use of the comma in a PRINT statement will use the two printing zones.

REMARKS AND EXPLANATIONS

We have avoided the use of REM statements in the programs themselves. Instead, to explain the programs, there are line-by-line descriptions. These explanations of the programs will help you to identify a line or variable's job.

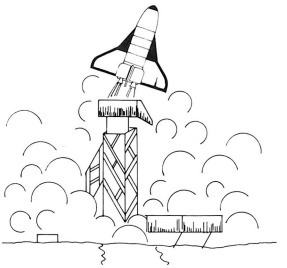
CATALOG PROGRAM

The catalog program can make life easier for you and your Apple. It will automatically catalog your disk each time that you insert it. With your disk in the drive, type in and run the program. Then type SAVE HELLO. The drive will whirr for a few seconds, and then display the prompt. From now on, your disk will show your name for a few seconds, and then show you what is on it.

Program Listing

```
10  HOME
20  PRINT "YOUR NAME"
30  FOR P= 1 TO 2000: NEXT P
40  HOME
50  D$ = CHR$ (4) :REM CTRL-D
60  PRINT D$;"CATALOG"
70  END
```

2



Adventures In Astronomy and Space Science

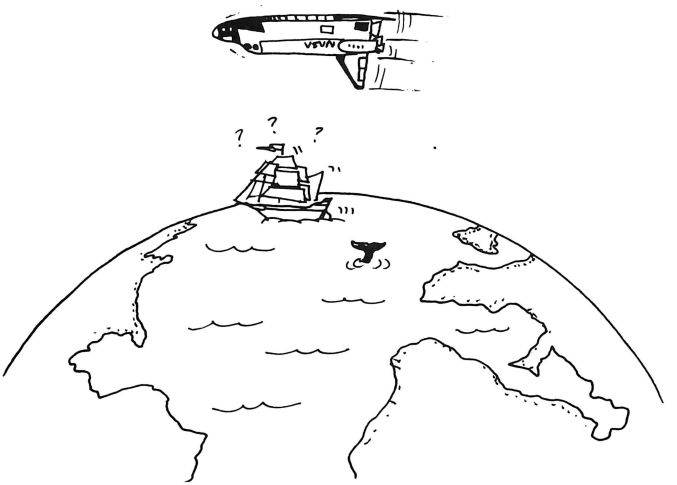
We start our adventures with a little jaunt — visiting nine planets, and covering over eight billion miles (round trip). On the way, we'll stop to explore local conditions, check on any satellites in the neighborhood, and give you a chance to live the life of an extraterrestrial. All this, in the comfort of your own home.

Thanks to your Apple, and some simple programs we've supplied, you can simulate all of this activity without an army of engineers or a fleet of spaceships.

So fasten your seatbelts, space cadets . . . Here we go!

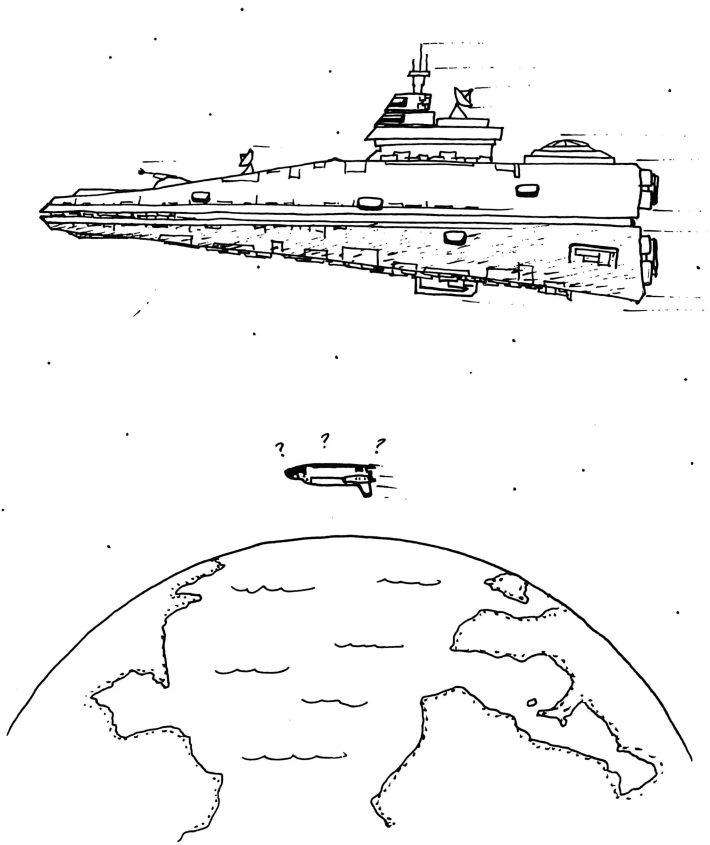
PLANETARY DISTANCES AND DIAMETERS

To anyone who travels a lot, it seems that the earth gets a little smaller with each new way to travel. It used to take years to go



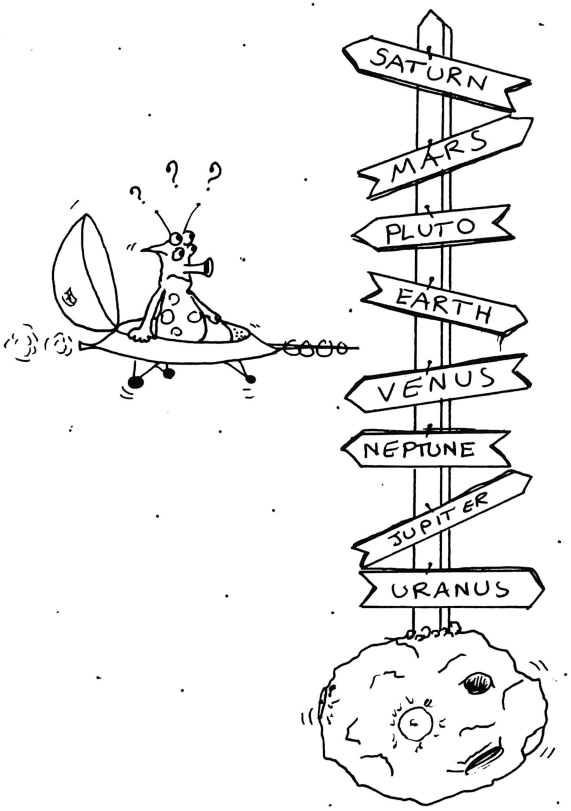
completely around the earth — now you can make the trip in ninety minutes. As you can see, the difference isn't really because the earth has shrunk, but because the vehicles are getting faster. In fact, your average space shuttle passenger travels farther in one orbit than the most sidetracked sailor ever did.

For the time being, it seems that we'll have to wait for another big breakthrough (atomic spaceships or something like that) before humans will travel much faster than they do at present. Until then, the biggest thrill we'll get is from the new places to which we are able

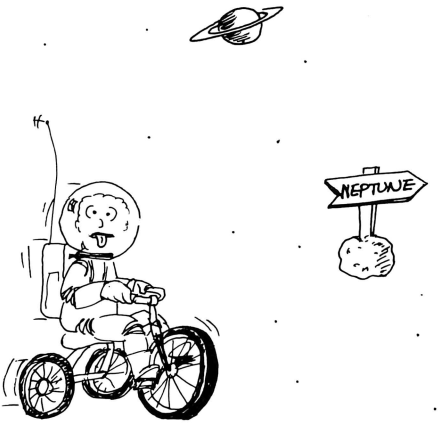


to travel. We've already sent robots to look at or land on most of the bodies in our solar system, and many people think that it's only a matter of time before we send some humans to those places too.

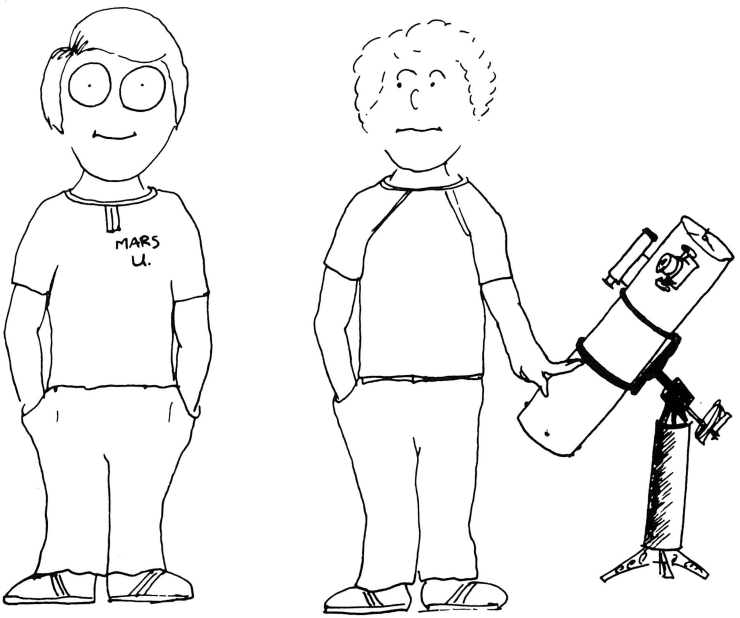
If and when we go to those places — Mars, Saturn, their moons, and all the rest — we'll need careful planning. "All the way out to the asteroid belt, then take your first left," just won't work at astronomical distances.



It would be nice to know the sizes of the planets. Then we would be prepared for navigating the ones with land or oceans or atmospheres. Touring Neptune might turn out to be a tiring task if all you have is your trusty tricycle. . .

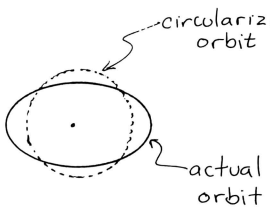


We can't see the solar system and judge its size using the equipment nature provided us with. Most parts of our solar system are too far away, and our eyes are too small and weak. There are two ways to get around this. We can either get bigger eyes (that's what a telescope is for), or get a smaller solar system. Making your own small solar system is easy, once you know the correct scale to make things. For instance, the sun's diameter is roughly 100 times as large as the earth's. This means that using a baseball as your earth model will send you searching for a sphere 27 feet in diameter to be used as the sun. Such objects aren't normally found lying around your average home or school.

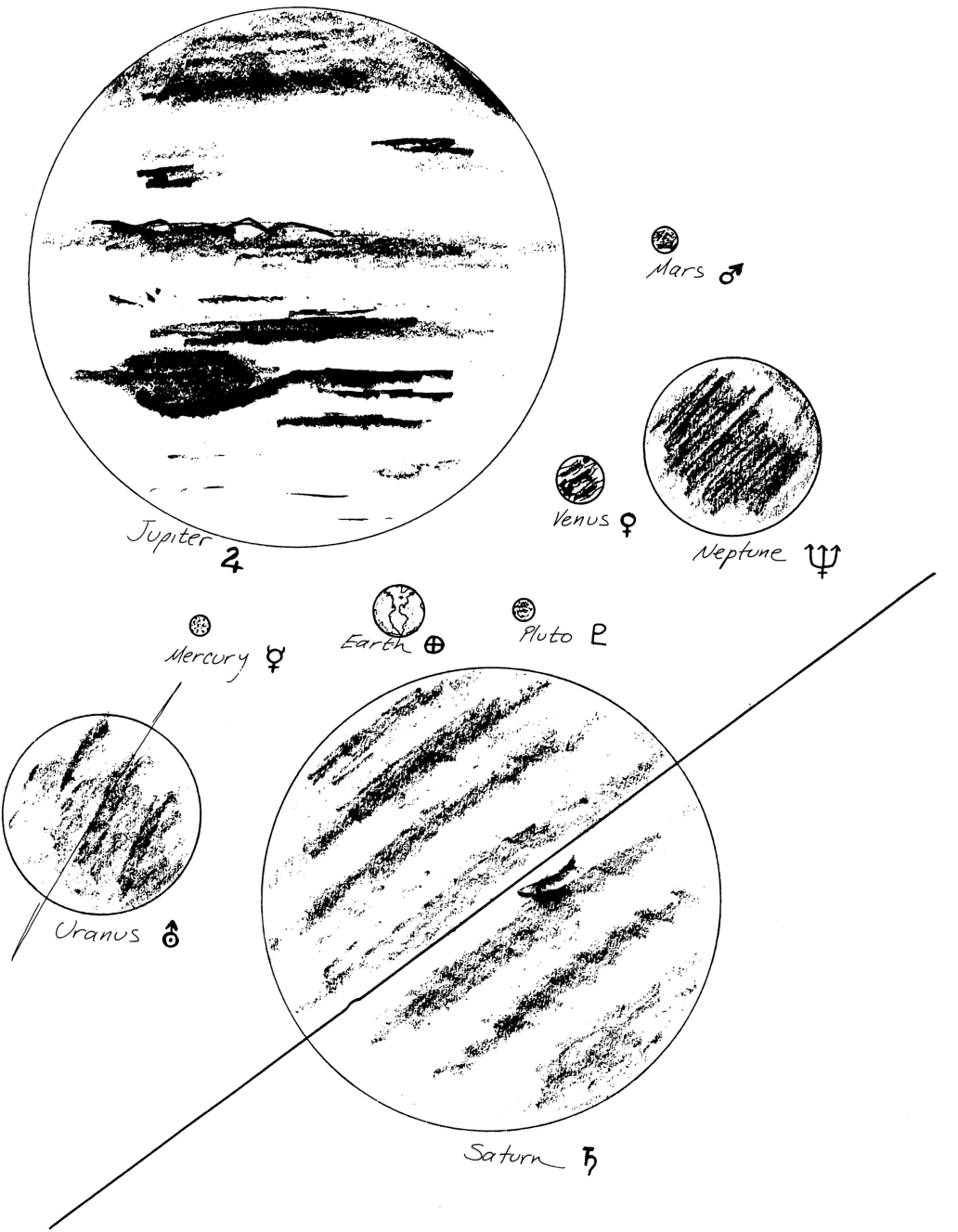


To make life building these models simpler, a program will do all the scaling of distances and diameters for you. All you need to do is tell it where you want your model to fit (the length of your shoebox, bedroom, classroom, gym, football field, etc.). It will tell you how large the planets must be and how far apart they must be to accurately model our solar system.

Note, however, that in the real solar system, the planets' orbits are ellipses, not circles. For the sake of simplicity and sanity, the computer will give you an orbit size that is an average between the longer and shorter diameters of the true ellipses.



The rest is up to your own wonderful imagination . . . an encyclopedia can give you maps of the planet surfaces for papier-maché globes, or, in a pinch, you can use golf balls, frisbees, tires . . . Bon Voyage!


Jupiter ♃
Mars ♂
Venus ♀
Neptune ♆
Mercury ☿
Earth ⊕
Pluto ♇
Uranus ♅
Saturn ♄

Program Listing

```
10  HOME
20  PRINT "          SCALED DISTANCES"
30  PRINT
40  PRINT "           AND DIAMETERS"
50  PRINT
60  PRINT "          FOR THE PLANETS"
70  PRINT
80  PRINT
90  PRINT " WHAT IS THE SIZE OF THE ROOM"
100  PRINT "THAT YOU WANT YOUR MODEL TO"
110  PRINT "FIT INTO (IN FEET)?"
120  INPUT M
130  PRINT
140  PRINT "THE FOLLOWING TABLE SHOWS HOW"
150  PRINT "BIG AND HOW FAR AWAY FROM THE"
160  PRINT "CENTER OF THE ROOM THE PLANETS"
170  PRINT "WOULD BE IF THE SUN WERE IN"
180  PRINT "THE CENTER AND PLUTO WAS ON"
190  PRINT "THE EDGE."
200  PRINT
210  PRINT
220  PRINT "PLANET"; TAB( 10);"CENTER(FT)"; TAB( 22);"DIAM(IN)"
230  PRINT
240  FOR I = 1 TO 9
250  READ P$,D1,D2
260 C = D1 * M / 5911.77
270 C =  INT (C * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
280 D = 12 * D2 * M / 5.91177E + 09
290 D =  INT (D * 10 ^ 6 + .5) /  INT (10 ^ 6 + .5)
300  PRINT P$; TAB( 10);C; TAB( 22);D
310  NEXT I
320  DATA  MERCURY,57.91,4868
330  DATA  VENUS,108.2,12112
340  DATA  EARTH,149.6,12756
350  DATA  MARS,227.94,6787
360  DATA  JUPITER,778.33,142830
370  DATA  SATURN,1429.99,119330
380  DATA  URANUS,2869.57,50800
390  DATA  NEPTUNE,4496.6,48600
400  DATA  PLUTO,5911.77,2900
410  END
```

Explanation

The variables for this program and the line-by-line explanation of its operation are given here.

m	the expected diameter of your model in feet
i	counter for planets
p$	planet name

d1 average planet distance from sun (in millions of kilometers)
d2 planet diameter (in km)
c scaled planet distance from your model sun (in feet)
d scaled planet diameter (in inches)

Lines 10-80. These lines print the introduction.

Lines 90-120. Asks for the size of the model which you would like to make.

Lines 130-210. Introduction and explanation for the chart which follows.

Lines 220-230. Prints the Header for the chart.

Line 240. Begins the loop of calculations for the nine planets.

Line 250. Reads the name(p$), distance(d1), and diameter(d2) of the nine planets.

Line 260. Calculates the scaled distance for the model, based on the ratio between your model size and the size of the solar system (times your model size m, divided by the real size 5911.77).

Line 270. Rounds off c to 3 decimal places.

Line 280. Calculates d, scaled diameter, based again on the ratio between scaled size and real size (you need the magnitude million here because you're not converting like-units as in line 260), then multiplies by 12 to convert to inches (believe us, feet is not the unit to be thinking of here unless your model is a few thousand feet wide).

Line 290. Rounds your diameter to six decimal places.

Line 300. Prints the results.

Line 310. The NEXT planet for line 240's FOR.

Lines 320-400. Data for the READ in line 250; the elements are name, distance in millions of km, and diameter in km.

Line 410. The end.

Sample Run

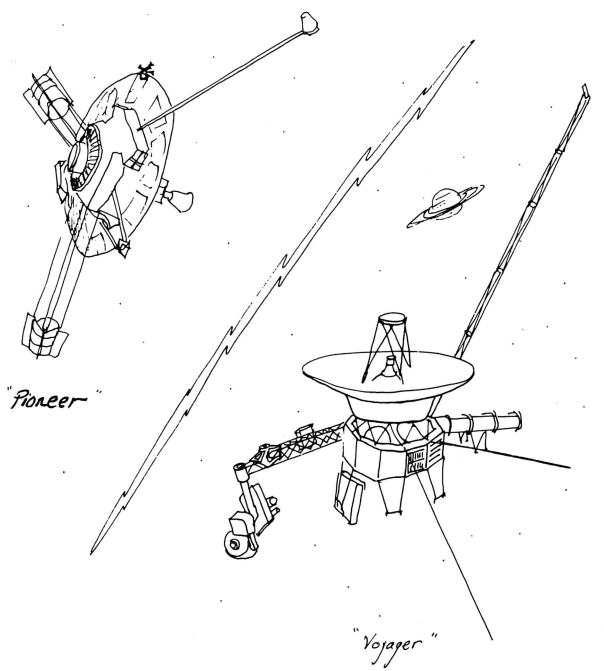
```
SCALED DISTANCES

 AND DIAMETERS

FOR THE PLANETS


 WHAT IS THE SIZE OF THE ROOM
THAT YOU WANT YOUR MODEL TO
FIT INTO (IN FEET)?
?50
```

THE FOLLOWING TABLE SHOWS HOW BIG AND HOW FAR AWAY FROM THE CENTER OF THE ROOM THE PLANETS WOULD BE IF THE SUN WERE IN THE CENTER AND PLUTO WAS ON THE EDGE.

PLANET	CENTER(FT)	DIAM(IN)
MERCURY	.49	4.94E-04
VENUS	.915	1.229E-03
EARTH	1.265	1.295E-03
MARS	1.928	6.89E-04
JUPITER	6.583	.014496
SATURN	12.094	.012111
URANUS	24.27	5.156E-03
NEPTUNE	38.031	4.933E-03
PLUTO	50	2.94E-04

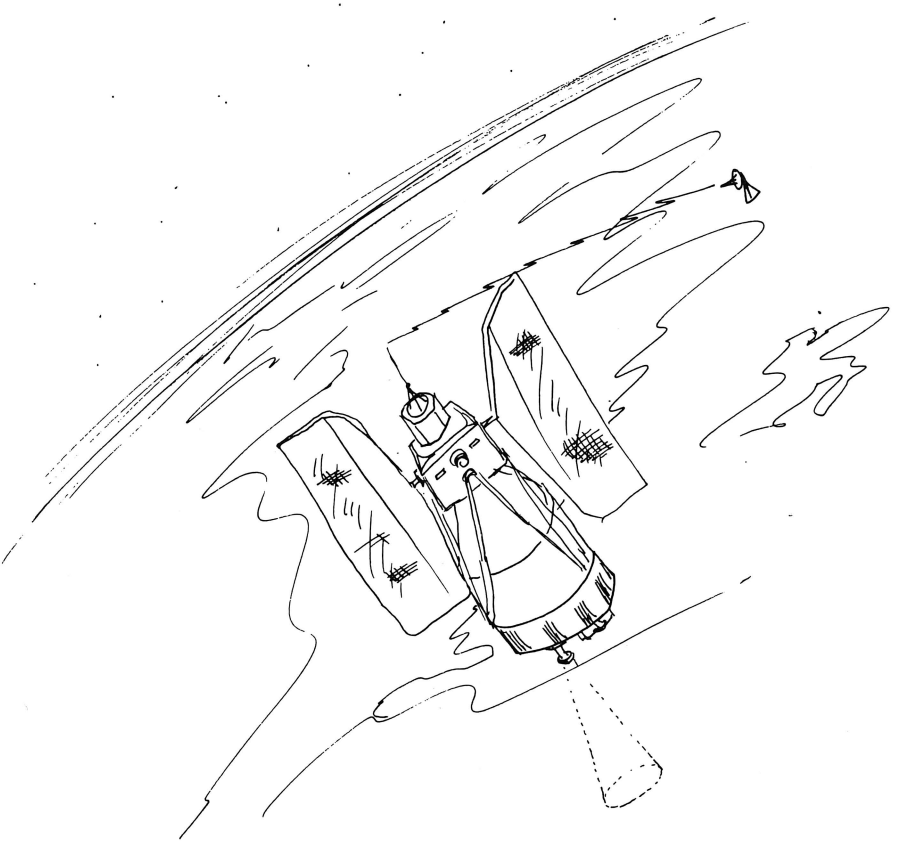
SATELLITE ORBITAL PERIODS

When you watch science fiction shows, you notice that the commanders usually send out "probes" before they get too close to the planet they're approaching. This is actually a pretty smart move. Better you should lose a probe to the mercy of a Rigelian Cloud Snake (ugh!) than your First Officer and Ship's Doctor.

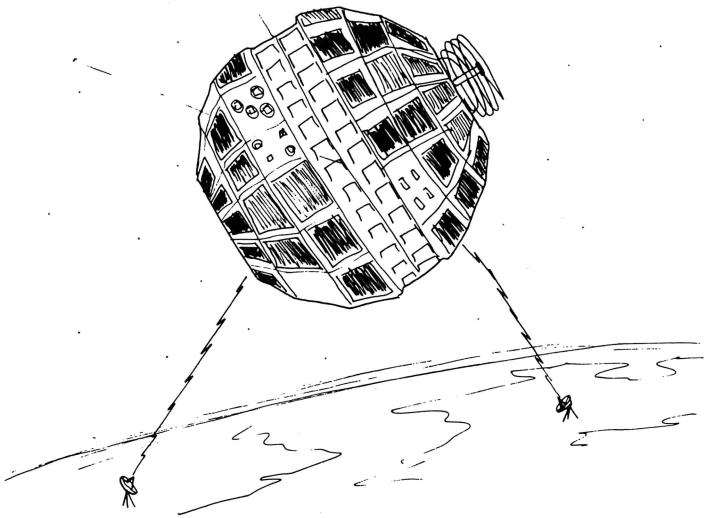


A probe is really just a highly specialized robot. We humans use them, and call them satellites if they orbit the earth (like Sputnik or Telstar), or spacecraft if they travel to another planet (like Pioneer or Voyager).

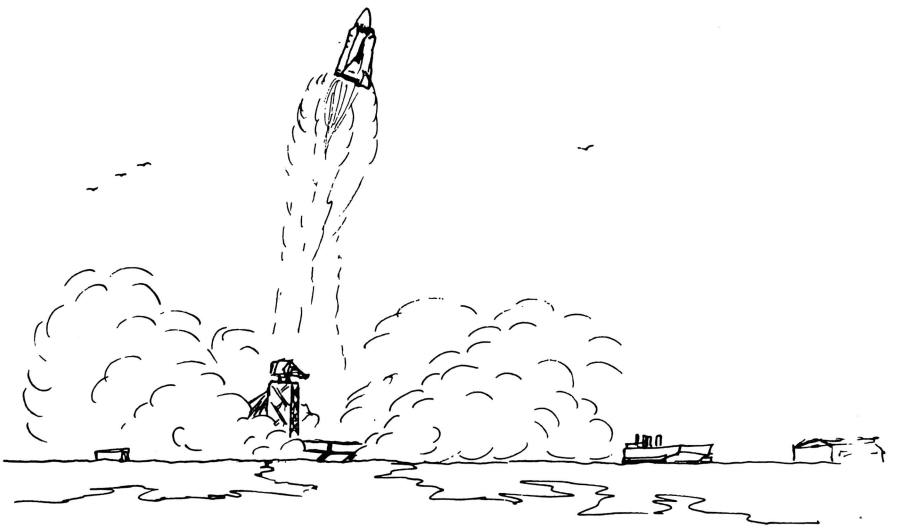
The satellites, or earth-orbiting probes, are designed to gather information, not about any extraterrestrials or distant worlds, but about the strangest world yet known — our own! It seems that sometimes, the best way to see what's going on down here is to step back (a few hundred miles) and get the big picture.



That's what most of our satellites do, they look. They look for earthquake sites, crop damage, forest fires, good weather, bad weather, and any other objects not easily seen from down here. Some satellites serve as ears, relaying signals to and from far apart places. Some can even repair or disable other satellites.



How do they get up there? We put them on top of a controlled explosion (a rocket) strong enough to get them as high as we need them.



How do we keep them up there? As long as the satellite is far enough away, and has a certain amount of energy, it will counteract the pull of the earth's gravity. How much energy? See the adventure on *escape velocity* for those details.

Johannes Kepler

How far away? Johannes Kepler figured that out years ago. He found that the square of the planet's (or satellite's) *period* (period × period) is equal to the cube of its distance from the "mother" planet or star (distance × distance × distance). Period is the time it takes for the planet or satellite to complete one revolution (orbit). Now that we've gotten these complex actions into mathematical form, they're fair game for your Apple. The program can go either way; if you know the distance, you can find out the period. If you know the period, it will figure out the distance.

And, if you'd like a little challenge, the program will give you a period or distance and ask you to guess (or calculate) the unknown.

Some special applications of this program would be to design custom orbits for satellites (or space stations) that need to be *geo-synchronous* (staying over a constant point on the surface) or super slow or super fast.

Happy landings!

Program Listing

```
10  HOME
20  PRINT "              COMPUTING SATELLITE"
30  PRINT "                ORBITAL PERIODS"
40  PRINT
50  PRINT
60 C = 5.245E - 09
70 T = 0
80 R = 6378
90 H =  INT (800000000 *  RND (S))
100 P = C *  SQR (H ^ 3)
110 P1 = P
120  PRINT " HOW HIGH DO YOU THINK A "
130  PRINT "SATELLITE MUST BE (IN"
140  PRINT "KILOMETERS) TO ORBIT THE "
150  PRINT "EARTH EVERY ";
160  GOSUB 310
170  INPUT H1
180 T = T + 1
190 H1 = 10000 * (H1 + R)
200 P1 = C *  SQR (H1 ^ 3)
210  IF  ABS (P1 - P) / P < 1E - 03 THEN 280
220  PRINT
230  PRINT "NOT QUITE.  YOUR SATELLITE"
240  PRINT "HAS A PERIOD OF"
250  GOSUB 310
260  PRINT " TRY AGAIN."
270  GOTO 170
280  PRINT "****   GOOD FOR YOU!   ****"
290  PRINT "YOU GOT IT IN ";T;" TRIES."
300  END
310 P4 =  INT (P1 / 1440)
320 P5 =  INT (P1 - 1440 * P4)
330  IF P4 = 0 THEN 350
340  PRINT P4;" DAYS, ";
350 P2 =  INT (P5 / 60)
360 P3 =  INT (P5 - 60 * P2 + .5)
370  PRINT P2;" HOURS, ";
380  PRINT P3;" MINUTES? "
390  RETURN
```

Explanation

The variables and the line-by-line explanations are as follows:

c constant to convert from astronomical units and years to meters and days/hours/minutes

t number of tries

r	radius of earth in kilometers
h	randomly selected altitude for the satellite, between zero and 8 million meters
p	period of the satellite picked by computer
p1	period of satellite picked by computer
h1	your guess for the altitude needed for that period (p1)
p4	period in days
p5	part of the period which is less than 1 whole day
p2	hours part of p5
p3	minutes part of p5
s	random number seed

Lines 10-40. Prints the introduction.

Lines 45-50. Asks for a number used to generate random numbers in line 90.

Lines 60-80. Sets values for c (conversion constant), t (number of tries), and r (metric radius of the earth).

Line 90. Picks a random orbital altitude between zero and 800,000,000 kilometers.

Line 100. Computes the period for that altitude based on p^2=h^3 (multiplied by the conversion constant for unit); to solve for p, you take the square root of the other side of the equation, so the p = square root of h^3.

Line 110. Moves the value for p into p1.

Lines 120-150. Asks for the altitude needed to keep the satellite orbiting with the following period.

Line 160. Goes to the subroutine (lines 310-390) that converts the period to days, hours, and minutes.

Line 170. Accepts your guess for the altitude.

Line 180. Adds 1 to your try count.

Line 190. Adds your guess to the radius of the earth, and converts to meters by multiplying by 1000.

Line 200. Computes the period for your guess, using the same method as line 100.

Line 210. Calculates the fraction of your guess that is in error. If this is less than .001, it means you've come close enough; if it is greater, it has you try again.

Lines 220-240. Announces that your error is too large.

Line 250. Goes to the subroutine which turns your period into days, hours, and minutes.

Lines 260-270. Asks you to try again and goes to the input at line 170.

Lines 280-300. Message displayed if your error is small enough and then ends the program.

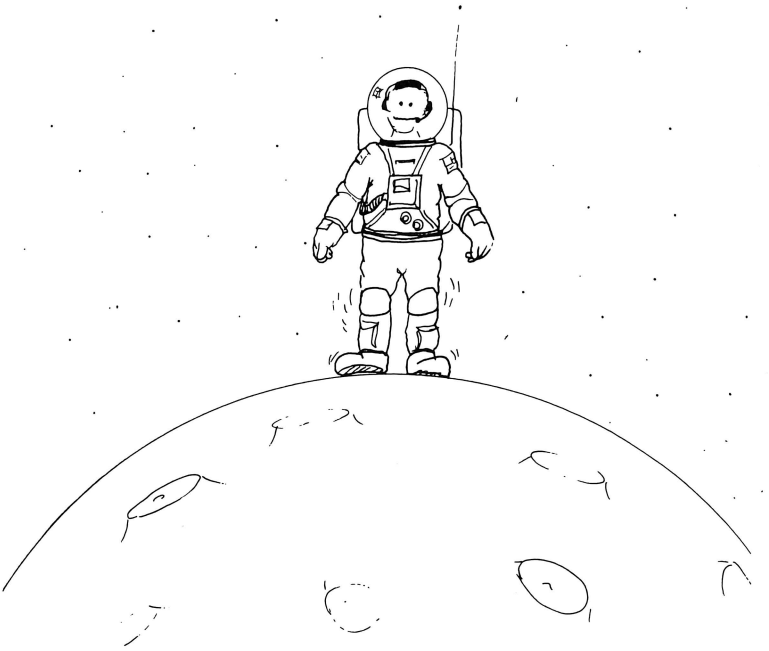
Lines 310-390. Subroutine to convert the period from minutes to days, hours, and minutes. 1440 = minutes per day. If there are less than 1440 minutes, it won't print any days; p5 is the leftovers from whole days; p2 divides this by 60 to find the number of hours; what's left over from that is divided by 60 to find p3, the number of minutes. Lines 340, 370, and 380 print these and then return to the line where they left off.

Sample Run

```
          COMPUTING SATELLITE
            ORBITAL PERIODS


 HOW HIGH DO YOU THINK A
SATELLITE MUST BE (IN
KILOMETERS) TO ORBIT THE
EARTH EVERY 60 DAYS, 6 HOURS, 20 MINUTES?
?600000

NOT QUITE.  YOUR SATELLITE
HAS A PERIOD OF
1719 DAYS, 21 HOURS, 7 MINUTES?
 TRY AGAIN.
?75000

NOT QUITE.  YOUR SATELLITE
HAS A PERIOD OF
84 DAYS, 13 HOURS, 20 MINUTES?
 TRY AGAIN.
?84000

NOT QUITE.  YOUR SATELLITE
HAS A PERIOD OF
98 DAYS, 23 HOURS, 8 MINUTES?
 TRY AGAIN.
```

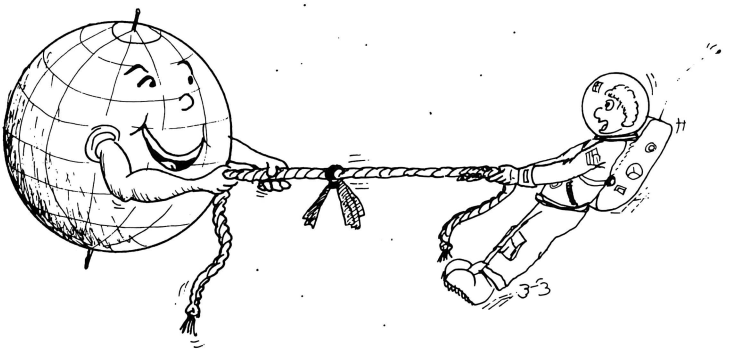
WEIGHT ON DIFFERENT PLANETS

It's pretty easy for most of us to get around on earth. That makes sense: our bodies have evolved and developed in the earth's gravitational field, and we would expect to be equipped with legs that can support our body.



Adventurers that we are, let's leave the earth and see what happens elsewhere. How will our legs do if we change the ground rules (no pun intended . . .)? Before we go, let's see what the experts have to say about what we should expect.

Gravity is a form of energy that causes a force to be exerted by



an object upon another object. It attracts the objects to each other. We don't yet know what carries this force, or exactly how it works (now *there's* a problem to solve), but we do know that it's there. If you have any doubts, try getting away from the earth and staying that way. (The trying is known as *jumping,* the proof of gravity known as *falling.* Please don't try this for too long, it tends to be painful.)

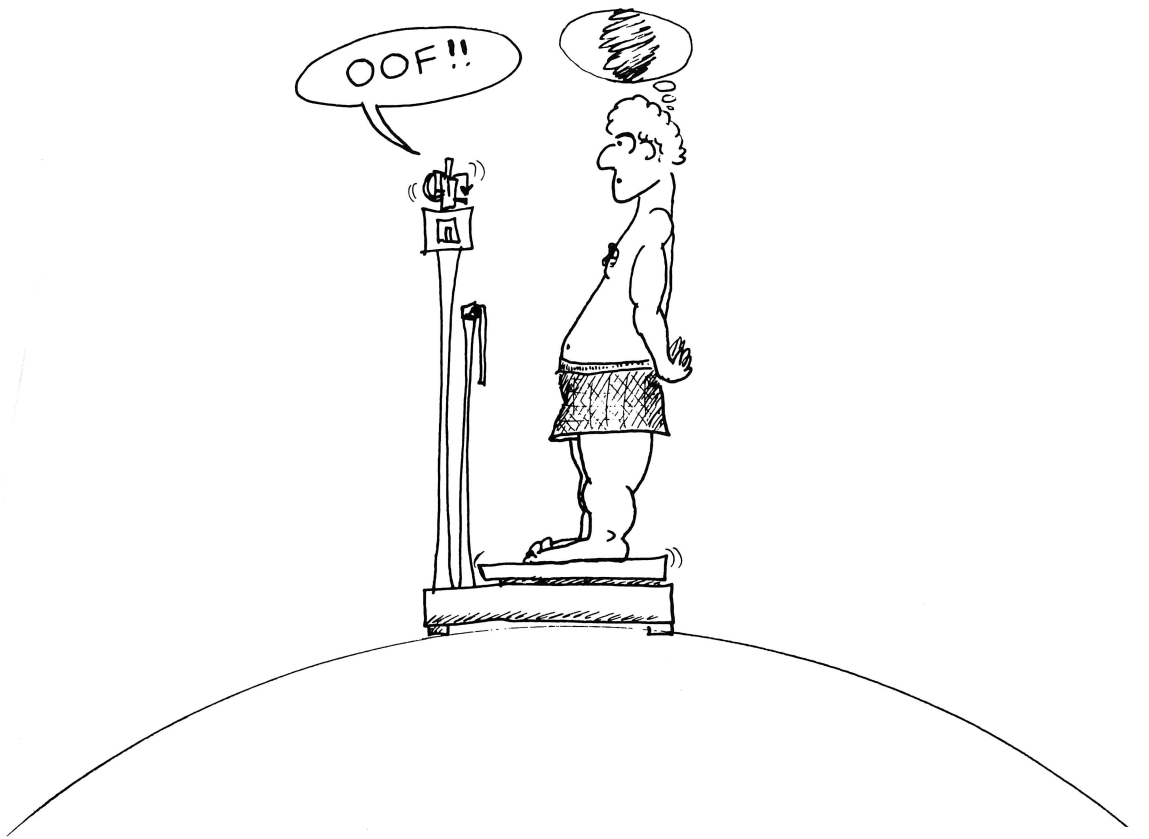
Sir Isaac Newton was the first person to develop a system for describing how gravity behaves. According to his reports, the more massive a body is, the more pull it exerts. To complicate things, the further away two objects are, the less attraction there is between them. (That's comforting when you consider how massive the sun is. . . .)

$$F = \frac{g \times m}{r^2}$$

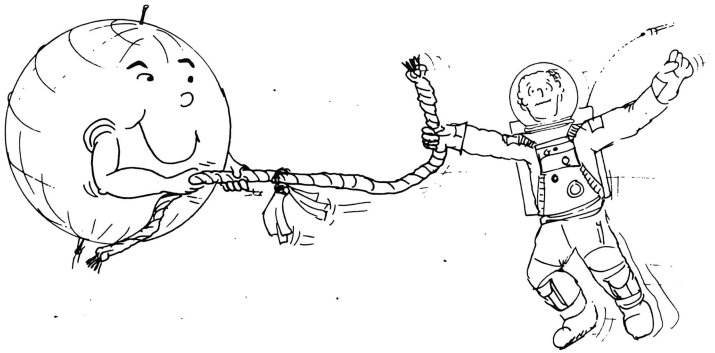
All of this can be written mathematically in a single equation that looks like the one in the margin.

As in all of our adventures, when we come across a useful equation, you can be sure that it will be somewhere in our Applesoft Basic program. This one, translated into Applesoft Basic, is in line 150.

Now we have a way for you and the Apple to figure out how much pull your local planet has on you. We call this pull "WEIGHT." It's what your scale measures when you put it between you and the planet.

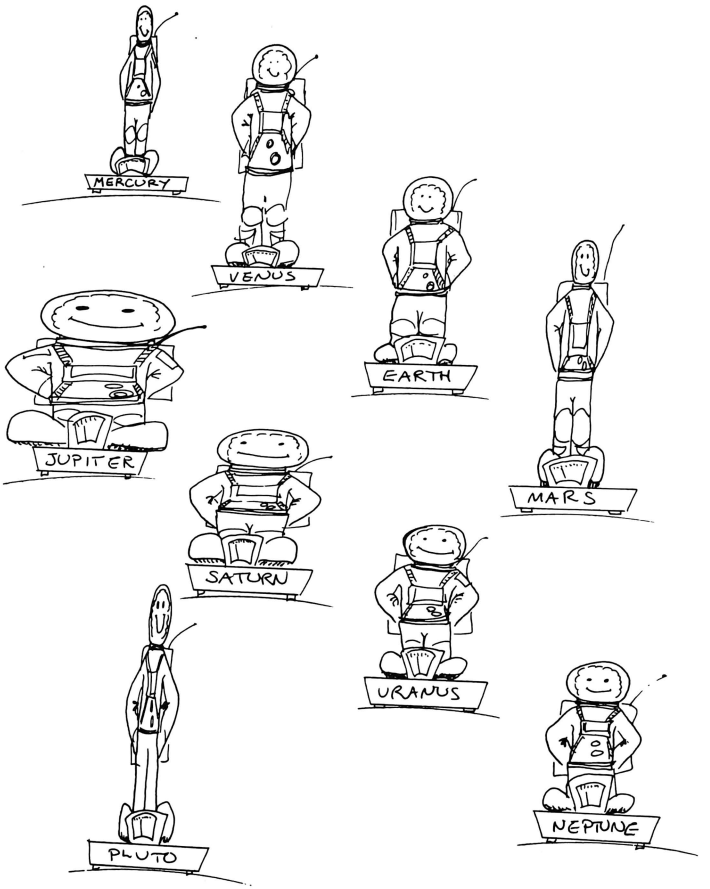


You might be pleased to know that you're pulling on the planet earth, too, but because you're so much less massive than the earth, it's rather difficult to measure that pull.



So far, so good. Now how about that adventure we promised you? First, let's get the Apple ready. As usual, type in the program for this adventure and check for errors.

To see what things are like on other planets, you'll need to tell the Apple what your weight is here on earth. It will tell you how much mass you have based on that weight, and then proceed to show you your weight on the other planets.



We did a little bit of homework for you and have included in the program the names and sizes (mass and radius) of the nine planets in our solar system. If you'd like, you can tell the Apple your own numbers, and see what it would be like on an asteroid, a particular moon, the sun itself (yikes!), a white dwarf star, or a neutron star. You can check the local library for the mass and radius of all of these astronomical oddities.

Happy Landings!

Program Listing

```
10  HOME
20  PRINT " WEIGHTS ON DIFFERENT PLANETS"
30  PRINT
40  PRINT
50  PRINT " WHAT IS YOUR WEIGHT?"
60  INPUT M1
70 M1 = M1 / 2.205
80  PRINT
90  PRINT "PLANET"; TAB( 10);"WEIGHT-KG"; TAB( 22);"WEIGHT-LBS"
100  PRINT
110 G = 6.67E - 11
120  FOR P = 1 TO 9
130  READ P$(P),M(P),R(P)
140 R(P) = R(P) * 1000
150 F(P) = G * M1 * M(P) / R(P) ^ 2
160 F(P) = F(P) / 9.8 * 2.205
170 F(P) =  INT (F(P))
180  PRINT P$(P); TAB( 14); INT (M1); TAB( 27);F(P)
190  NEXT P
200  DATA    MERCURY,2.99E+23,2424
210  DATA    VENUS,4.90E+24,6128
220  DATA    EARTH,5.98E+24,6378
230  DATA    MARS,6.46E+23,3380
240  DATA    JUPITER, 1.90E+27,71370
250  DATA    SATURN,5.69E+26,60400
260  DATA    URANUS,8.67E+25,23790
270  DATA    NEPTUNE,1.05E+26,22259
280  DATA    PLUTO,5.98E+23,2998
290  END
```

Explanation

Listed below are the variables for the program. The line-by-line explanation follows.

m1	your weight converted to kilograms of mass
	universal
g	gravitational constant
p	counter for the planets
p$	planet name

m	planet's mass (in kg)
r	planet's radius (in km)
f	force exerted on your body due to gravity on the planet (your weight)

Lines 10-40. Prints the introduction.

Lines 50-70. Asks for your earth weight in pounds, then converts this to mass in kilograms (at 2.205 pounds per kilogram).

Lines 80-100. Prints Header for chart of mass and weights.

Line 110. Sets g = .0000000000667, the universal gravitational constant.

Line 120. Begins the loop to do calculations for all nine planets.

Line 130. Reads the data from lines 200-280. The first element is the name, the second is the mass, and the third is the radius.

Line 140. Converts radius to actual value. You could skip this step and add three zeros to each radius in the data statements, but doing it as a step saves space.

Line 150. The Applesoft Basic version of the equation which you saw in the text (force equals gravitational constant times your mass times the planet's mass, all divided by the square of the radius).

Line 160. Converts this force (in newtons) to pounds (at 1/9.8 kilograms per newton and 2.205 pounds per kilogram).

Line 170. Turns f into an integer. Once you see how large these can be, the decimal places become unimportant.

Line 180. Prints the planet name, your mass, and your weight on that planet.

Line 190. NEXT planet for line 120's FOR.

Lines 200-280. Data for the planets (name, mass, and radius in thousands of km).

Line 290. The end.

Sample Run

```
 WEIGHTS ON DIFFERENT PLANETS

 WHAT IS YOUR WEIGHT?
?110

PLANET    WEIGHT-KG    WEIGHT-LBS

MERCURY       49            38
VENUS         49            97
EARTH         49            110
MARS          49            42
```

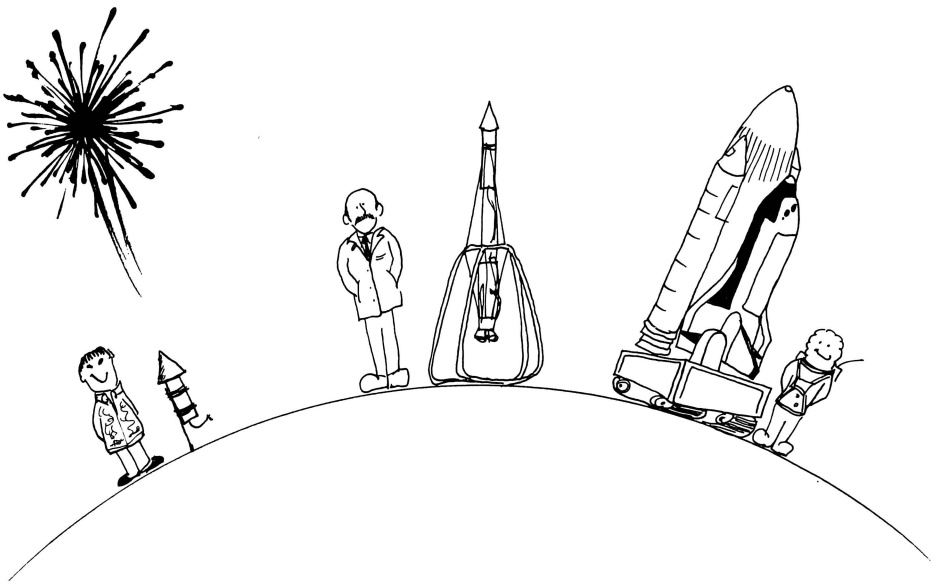
JUPITER	49	279
SATURN	49	116
URANUS	49	114
NEPTUNE	49	158
PLUTO	49	49

ESCAPE VELOCITY

This program has nothing to do with prisons or dungeons. (Sorry.) It does have to do with escaping, but from the gravitational field (pull) of a large, massive body (planet).

Naturally, if our last adventure left you on some strange planet checking your weight, the least we can do is show you how to get off of that planet. We don't want any of you to be late for supper.

The usual way to get off of a planet is with a rocket. Depending on how far away you want to get, you use a different type of rocket.

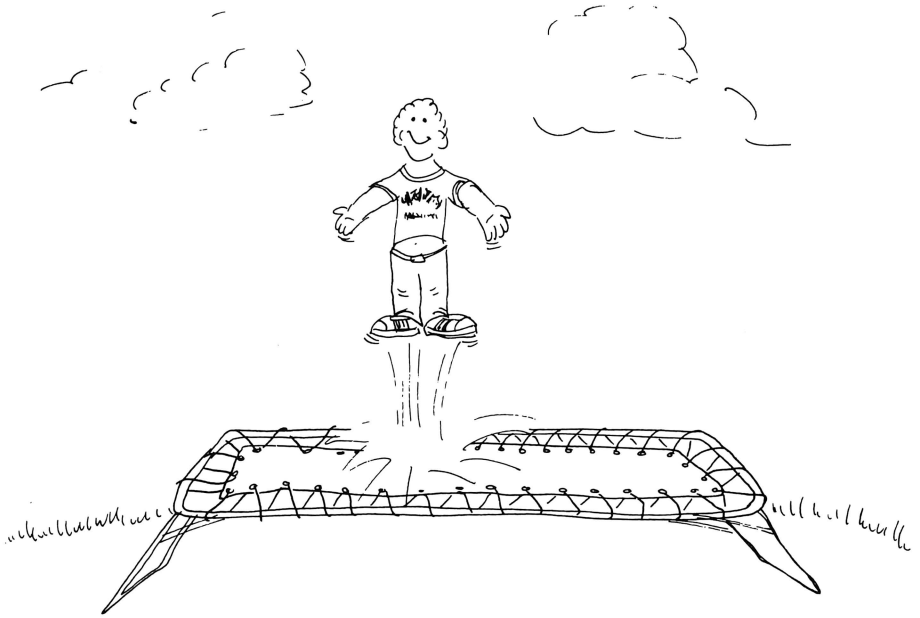


The Chinese wanted to propel their fireworks into the air for festivals, so they used small, inexpensive rockets. Robert Goddard simply wanted to prove that rockets could be safely launched and recovered, so his were no bigger than necessary to get themselves off the ground.

Nowadays, we need to use rockets to put other objects (*pay-*

loads) into orbit and keep them there. These rockets, therefore, must be designed to quickly lift far more than their own weight.

In the last adventure, you tried to escape from the earth's pull by jumping. You contracted the muscles in your legs, and gave yourself some *velocity* (speed). If you are still reading this, the velocity



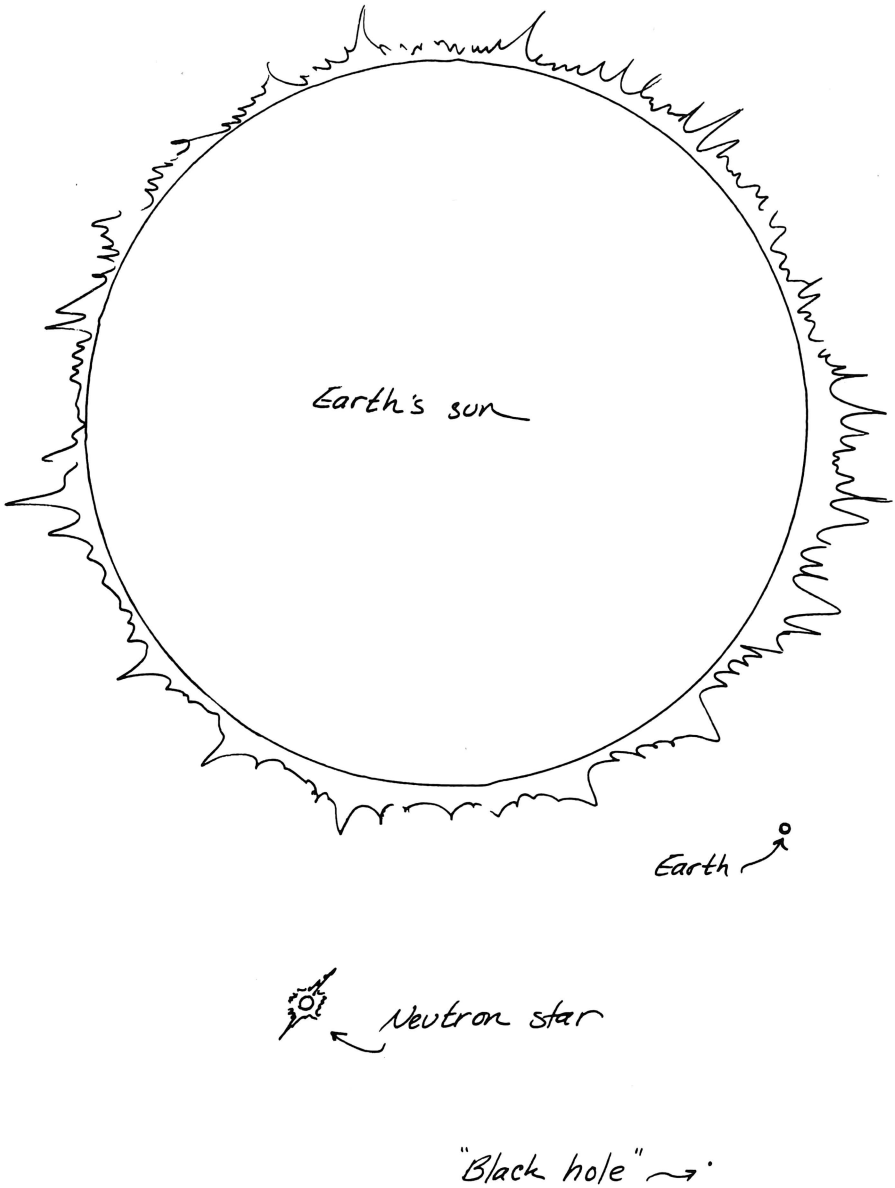
wasn't enough to counteract the earth's pull. Just as there's a certain amount of pull that each planet has, there's a certain amount of velocity you must have if you are going to escape that pull. As you might have already guessed, this is known as *escape velocity.*

$$F = \frac{g \times m}{r^2}$$

As with gravitational attraction, the amount of escape velocity you need depends on the mass and radius of the planet in question. The first equation that the program uses (shown in the margin) looks like one in our last program. It will figure out the pull exerted by a planet. The "g" that results is used in a second equation.

This equation (line 180 in the program) is the one that figures out the escape velocity. It, too, depends on the radius of the planet. What is interesting here is that you can keep the same mass in several examples, and only change the radius. This is what actually happens when a star becomes a white dwarf, then a neutron star, and finally a black hole.

$$V_e = \sqrt{2 \times g \times r}$$



A *black hole* is defined, by the way, as a star whose escape velocity is higher than the speed of light. That's why it's black — not even light can get away from it to reach your eyes. You might want to figure out, by changing radiuses, how small the earth would have to become in order to be a black hole. (Never fear: because the earth isn't a star, this will never actually happen.)

Program Listing

```
10  HOME
20  PRINT "      ESCAPE VELOCITY"
30  PRINT
40  PRINT "            AND"
50  PRINT
60  PRINT "      GRAVITATIONAL PULL"
70  PRINT
80  PRINT
90  PRINT "WHAT IS YOUR PLANET'S NAME?"
100  INPUT P$
110  PRINT
120  PRINT "WHAT IS ITS MASS (IN KG)?"
130  INPUT M
140  PRINT
150  PRINT " WHAT IS ITS RADIUS (IN KM)?"
160  INPUT R
170 R = R * 1000
180 G = 6.67E - 11 * M / R ^ 2
190 GF = G * 3.281
200 V =  SQR (2 * G * R)
210 VM = V * 1E - 03 * .62137 * 3600
220  PRINT
230  PRINT "THE GRAVITATIONAL PULL OF"
240  PRINT P$;" IS ";G;" METERS"
250  PRINT "PER SEC PER SEC OR"
260  PRINT GF;" FEET PER SEC"
270  PRINT "PER SEC."
280  PRINT
290  PRINT P$;"'S ESCAPE VELOCITY IS"
300  PRINT V;" METERS PER"
310  PRINT "SECOND OR ";VM;" MILES"
320  PRINT "PER HOUR."
330  END
```

Explanation

The variables and program explanation are given here.

p$	the planet's name
m	the planet's mass (in kilograms)
r	the planet's radius (in kilometers)
g	gravitational pull (in meters/sec/sec)
gf	gravitational pull (in feet/sec/sec)
v	escape velocity in meters per second
vm	escape velocity in miles per second

Lines 10-80. Prints the introduction.

Lines 90-110. Asks for planet's name.

Lines 120-140. Asks for planet's mass in kilograms (6 trillion metric tons would be 6,000,000,000,000,000 kilograms!).

Lines 150-170. Asks for the planet's radius in kilometers (the way you usually find it in books), line 170 converts radius from kilometers to meters.

Line 180. Calculates gravitational pull: 6.67 × 10^−11 is the universal gravitational constant, which when multiplied by the mass of the planet and divided by the square of the radius, gives you gravitational pull (notice as the planet gets heavier, the pull gets greater, but the further you are from the planet, the smaller the pull).

Line 190. Converts metric pull to English pull at 3.28 feet per meters.

Line 200. Calculates escape velocity, which equals the square root of two times the pull (g) times the radius.

Line 210. Converts metric escape velocity to English escape velocity (at .001 meters per kilometer; 0.62137 kilometers per mile; and 3600 seconds per hour).

Lines 220-330. Displays gravitational pulls (both formats) and escape velocities (both formats).

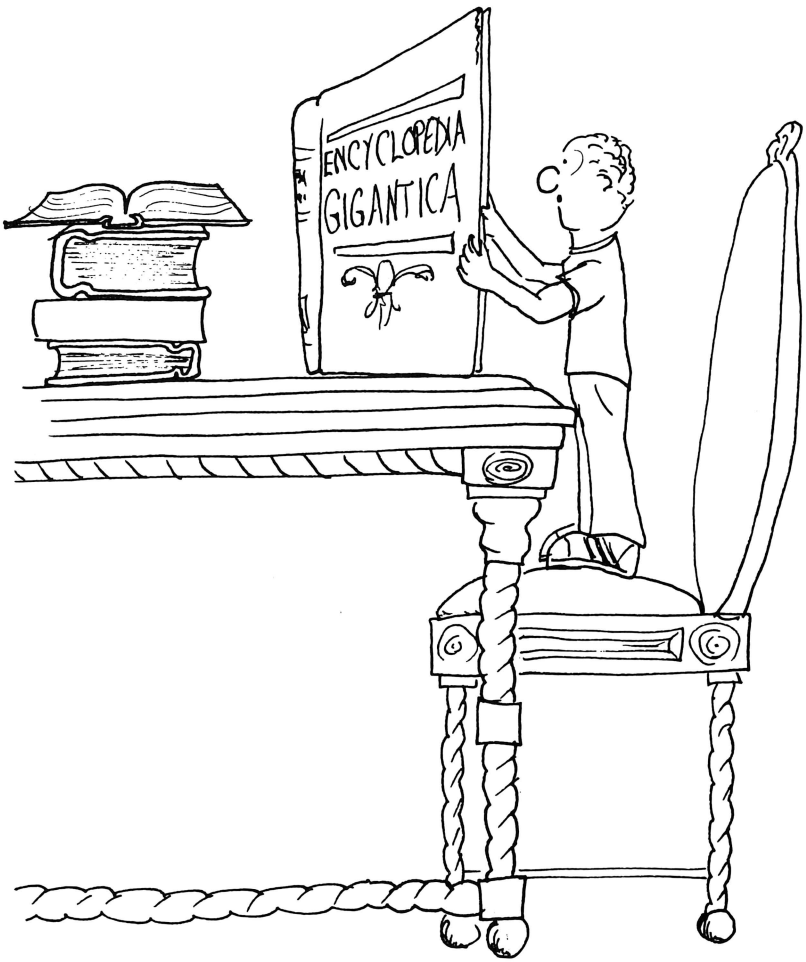
Sample Run

```
ESCAPE VELOCITY

      AND

GRAVITATIONAL PULL


WHAT IS YOUR PLANET'S NAME?
?GRINDUK

WHAT IS ITS MASS (IN KG)?
?698000000

 WHAT IS ITS RADIUS (IN KM)?
?34500

THE GRAVITATIONAL PULL OF
GRINDUK IS 3.91149758E-17 METERS
PER SEC PER SEC OR
1.28336236E-16 FEET PER SEC
PER SEC.
```

```
GRINDUK'S ESCAPE VELOCITY IS
5.19512592E-05 METERS PER
SECOND OR 1.16211434E-04 MILES
PER HOUR.
```

DISTANCE TO THE SUN

To be perfectly honest, the easiest way to find the distance from the earth to the sun is to look it up in the encyclopedia.



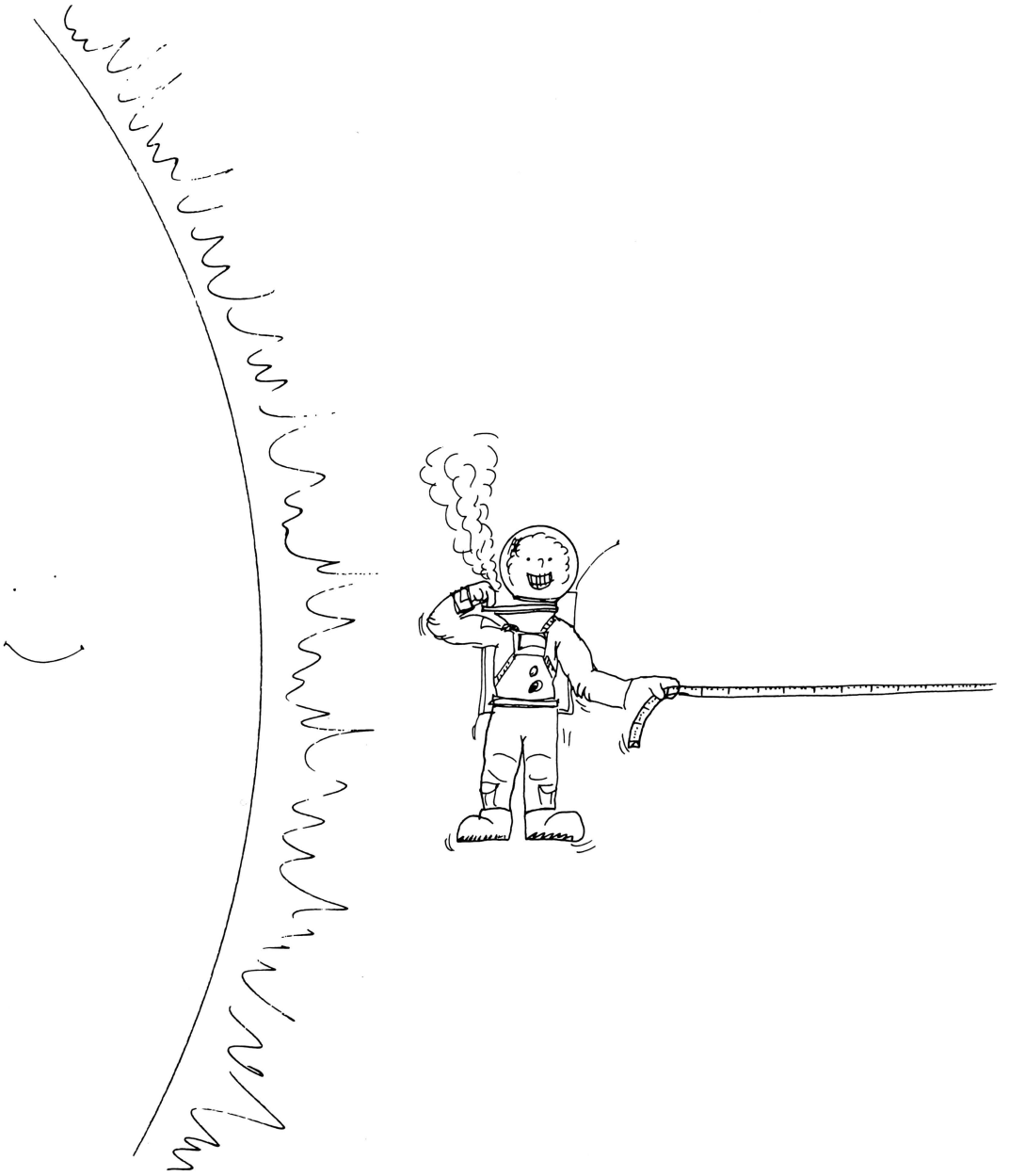
But it's hardly the best way. And we didn't always have books to rely on. Somebody had to be the first one to calculate the distance from the earth to the sun.

People have not always had a good idea of where the sun was. According to Greek mythology, Daedelus, with wings made of feathers and wax, flew too close to the sun, and its heat melted his

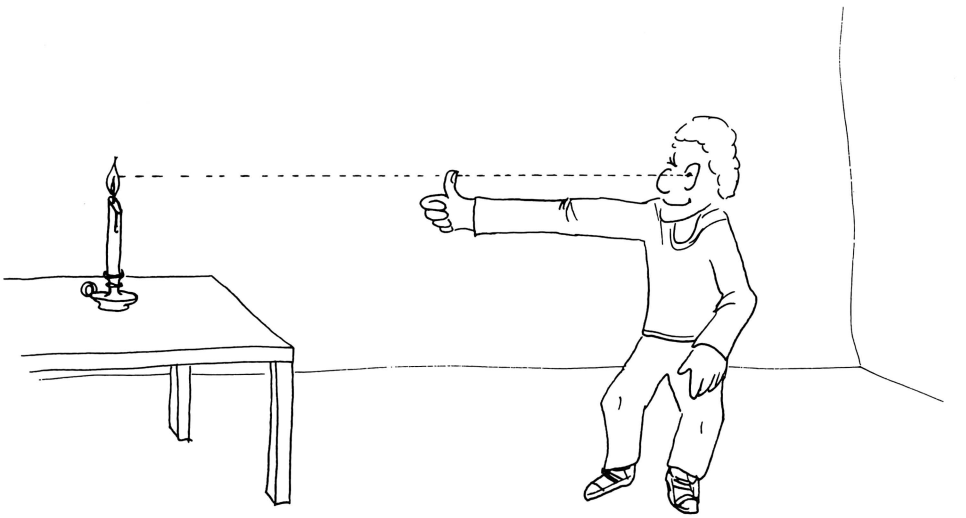
OOPS.

wings. This story was perfectly acceptable to people who were estimating the distance to the sun based on the image they saw and the heat they felt. Life isn't quite that simple. What was needed was a method of measurement.

There's one problem: direct measurement is tricky when you're dealing with the sun. How would you like to be the one holding the far end of the tape measure?

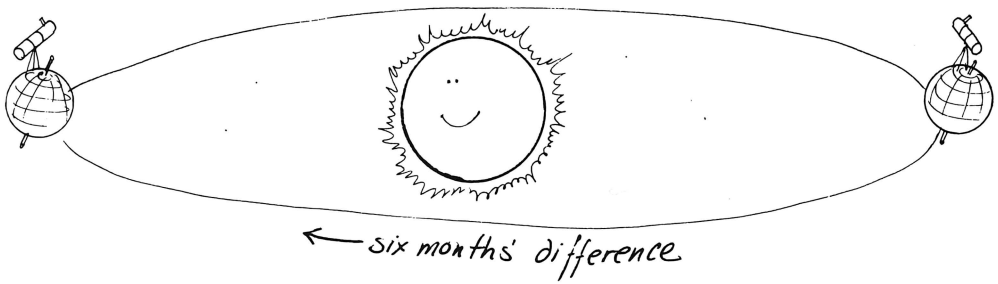


Let's try an *indirect* method of measurement. There are a few of these to pick from. One method involves the use of ***parallax***, the apparent change in position of a faraway object when the viewpoint is changed. You can see the effect of parallax by closing one eye, lining up an outstretched hand with a distant object, and then alternating closing one eye and then the other. See the effect?



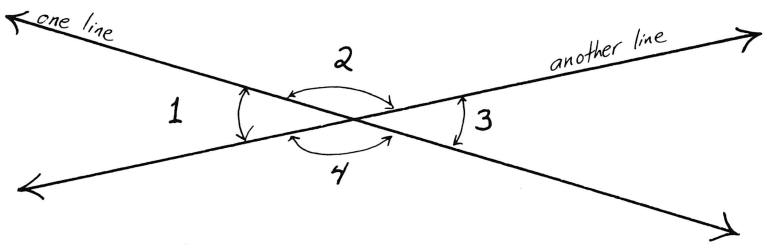
Parallax is also responsible for all of those snapshots of Aunt Gertie's knees, when you were SURE that you had her lined up just right in the viewfinder. The viewfinder and lens on some cameras have different viewpoints.

When astronomers measure the distance to the stars with this method, they don't blink. Instead, they put their "eyes" (telescopes) at viewpoints as far apart as possible (for example, two views, six months apart, as the earth orbits the sun), and measure the apparent shift. From this, they can calculate the distance that the shift repre-



sents. The laws of *trigonometry* (angle measurement) dictate the relationship between angles and distance.

The simpler method, which we will use, draws on trigonometry, too. To use it, we rely on the fact that when two lines cross, they can only create two different angle sizes. The angles that lie across from

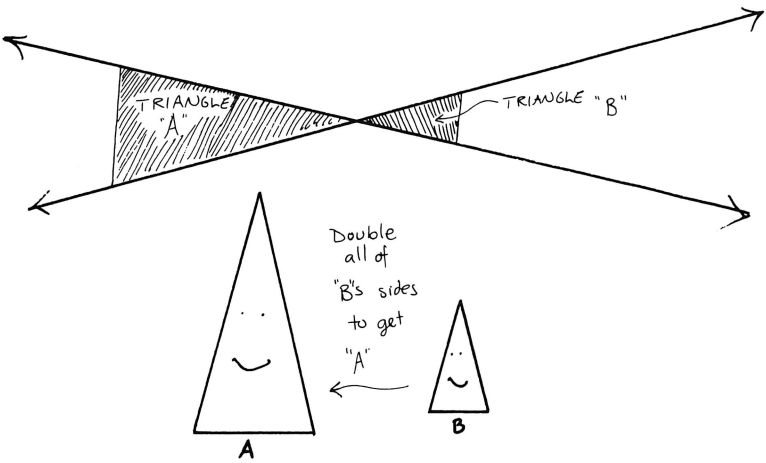


angle 1 = angle 3

and

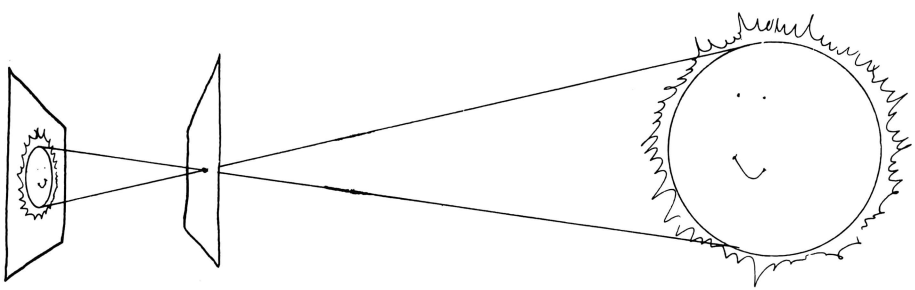
angle 2 = angle 4

each other will always have the same measure. If you make triangles out of two of these angles, the triangles will be similar. This means that even if their sizes are not the same, the relative lengths of the sides stay the same. If you multiply the sides of the small triangle by



some number, you can get the lengths of the sides of the large triangle.

That's what we're going to do. The triangles are made using a pinhole in an index card as the point of intersection. The (very) far side of the large triangle is the diameter of the sun itself, and the far side of the other triangle will be formed by the image of the sun on another index card.



Hold the two cards parallel, with the pinhole card closest to the sun (see the picture above). You will need to record two numbers: the size of the sun's image on the lower card, and the distance between the two cards. (This is the same way that you make a pinhole camera, packing it all in a nice dark box.)

You need a sunny day to do this. If it's cloudy, see the next chapter to do the adventure on identifying cloud types until it clears up.

The program for this adventure needs the distances you've measured, and it will then tell you the distance from you to the sun. For some "further adventures," try this several times, and take an average (to reduce the effect of any errors in your measurements). Have your friends do the same, and try to get as close as possible to a textbook value for the distance. How do you get a textbook value? Why, you go to your nearest encyclopedia, of course!

```
10  HOME
20  PRINT "      DISTANCE TO THE SUN"
30  PRINT
40  PRINT
50  PRINT "USING THE CARD ACTIVITY"
60  PRINT "MENTIONED IN THE TEXT YOU"
70  PRINT "CAN ESTIMATE THE DISTANCE FROM"
80  PRINT "YOUR SPOT ON EARTH TO THE SUN."
```

```
90  PRINT
100  PRINT "WHAT IS THE DIAMETER OF THE"
110  PRINT "SUN'S IMAGE ON THE CARD"
120  PRINT "(IN CM)?"
130  INPUT D
140  PRINT
150  PRINT "WHAT IS THE DISTANCE FROM THE "
160  PRINT "PINHOLE CARD TO THE IMAGE"
170  PRINT "CARD (IN CM)?"
180  INPUT S
190 DS = S * 1392000 / D
200 P =  ABS ((150000000 - S * 1392000 / D) / 150000000) * 100
210 DS =  INT (DS * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
220 P =  INT (P * 10 ^ 2 + .5) /  INT (10 ^ 2 + .5)
230  PRINT
240  PRINT "THE ESTIMATED DISTANCE TO THE"
250  PRINT "SUN IS ";DS;" KM."
260  PRINT "YOUR PERCENTAGE OF ERROR IS "
270  PRINT P;"%."
280  IF P > 20 THEN 350
290  PRINT
300  PRINT "THAT'S A PRETTY GOOD RESULT."
310  PRINT "CHECK THAT AGAINST THE AVERAGE"
320  PRINT "DISTANCE WHICH IS THE 150,000,000"
330  PRINT "OR 1.5 X 10^8 KILOMETERS."
340  GOTO 380
350  PRINT
360  PRINT "WHY DON'T TOU TAKE THOSE"
370  PRINT "MEASUREMENTS OVER AGAIN."
380  END
```

Explanation

The variable list is shown here. The line-by-line explanation follows.

d	diameter of the sun image on the card
s	distance from pinhole to image
ds	calculated sun distance
p	percent error of ds as compared to the actual value

Lines 10-90. Prints the introduction.

Lines 100-130. Asks for the diameter of the sun's image and the pinhole card.

Lines 140-180. Asks for the distance between the image and the pinhole card.

Line 190. Calculates distance to the sun based on the ratio of the image to the distance (sun dist/sun diam = 107.758) and the actual diameter (1392000 km).

Line 200. Calculates the percent error by comparing your results with the known results (textbook values).

Lines 210-220. Rounds distance to three decimal places and error percentage to two decimal places.

Lines 230-270. Displays the results.

Line 280. Checks to see if your percentage of error is high (20 percent or more). If it is, the program goes to line 350. If not, it goes to 290.

Lines 290-340. These print a message if your percentage of error is less than 20 percent, and then end the program.

Lines 350-370. If error is greater than 20 percent, suggests that you try again.

Line 380. The end.

Sample Run

```
   DISTANCE TO THE SUN


USING THE CARD ACTIVITY
MENTIONED IN THE TEXT YOU
CAN ESTIMATE THE DISTANCE FROM
YOUR SPOT ON EARTH TO THE SUN.

WHAT IS THE DIAMETER OF THE
SUN'S IMAGE ON THE CARD
(IN CM)?
?.5

WHAT IS THE DISTANCE FROM THE
PINHOLE CARD TO THE IMAGE
CARD (IN CM)?
?55

THE ESTIMATED DISTANCE TO THE
SUN IS 153120000 KM.
YOUR PERCENTAGE OF ERROR IS
2.08%.

THAT'S A PRETTY GOOD RESULT.
CHECK THAT AGAINST THE AVERAGE
DISTANCE WHICH IS THE 150,000,000
OR 1.5 X 10^8 KILOMETERS.
```

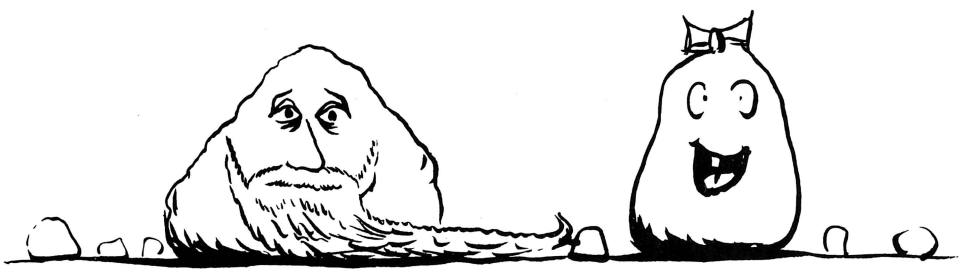
3

Adventures in Earth Science

Now that we've given you a tour of the solar system, we're going to get your feet back on solid ground. This group of adventures is designed to help you understand and decipher the earth. We'll investigate the way it operates, its makeup (geology) and its environment (weather and climates). We'll even show you a way to measure the earth's size in the comfort of your own backyard! Onward ho!

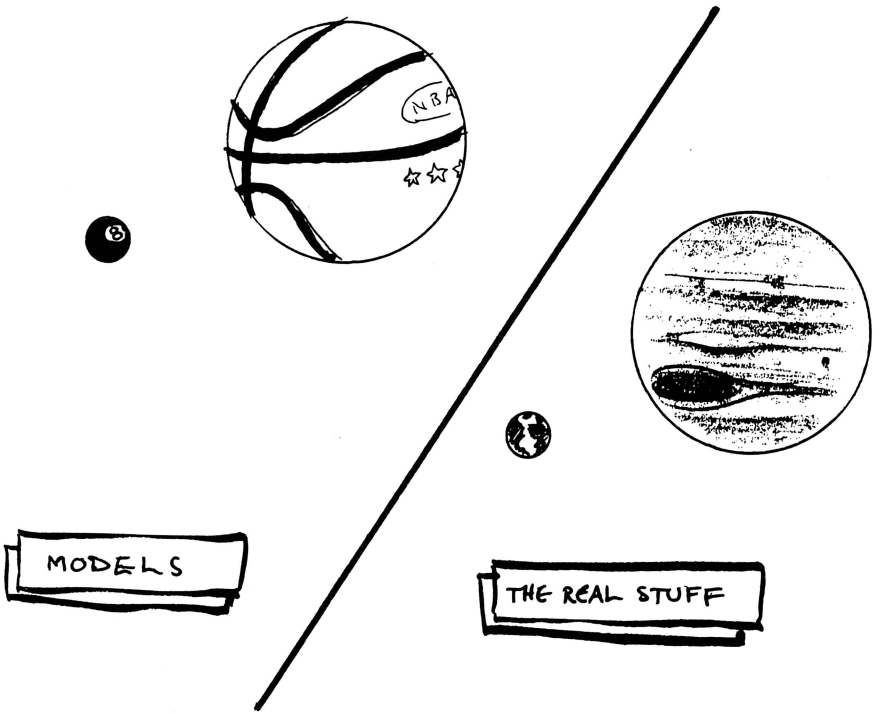
A GEOLOGICAL TIME CLOCK

The earth has been around for a long time. Scientists have been able to estimate how long by various methods. Some of these compare the amount of radiation which an old rock gives off to the amount which a new rock gives off. This gives us a clue to how long the rock has been radiating, which is its age. The oldest rocks found on the earth are roughly four billion years old. A billion is a lot. For instance, it's been about a billion seconds since World War II. It's been a billion minutes



since we began counting Years A.D. That's getting a little hard to picture.

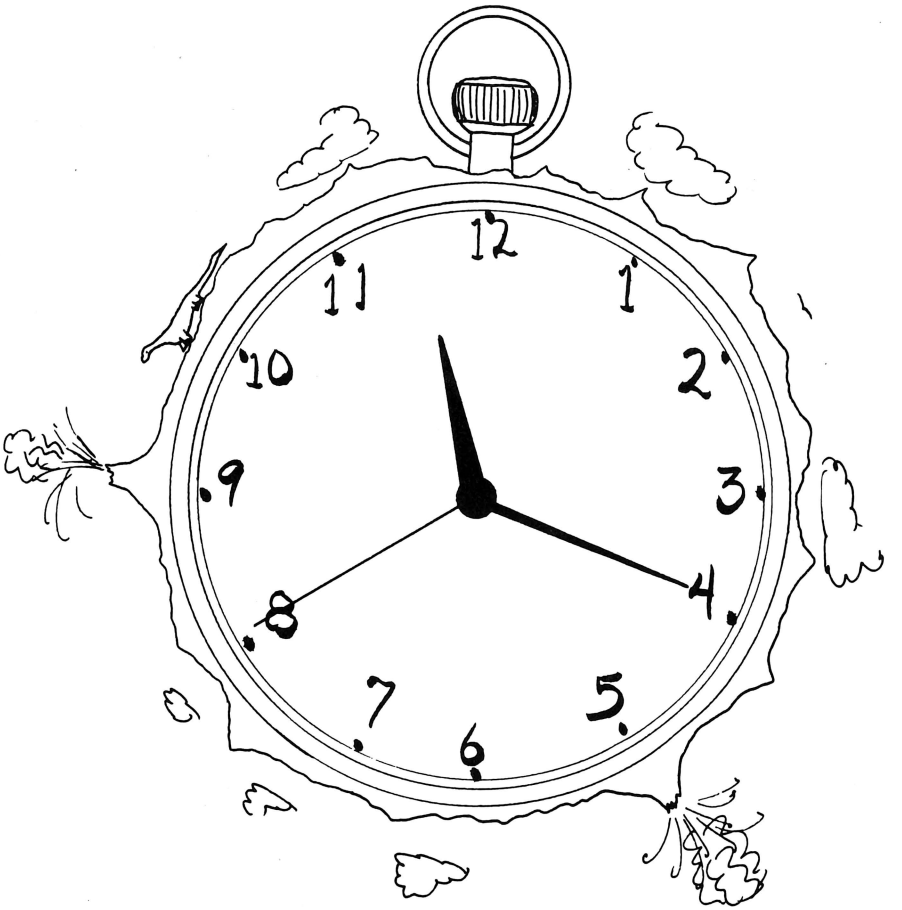
To understand a billion years, let's use a trick we used to understand distances in the first chapter. We'll make a model. So far, the models we have used have helped us to scale distances. We have



simply used things (golf balls, frisbees, etc.) which are smaller than, but similar to, the real objects (Mars, Saturn, etc.).

This model will be built the same way. Because we're trying to understand time, let's get some "smaller" time. You all have a fairly good idea of how long a day is, so let's scale our earth's history so that the entire four billion years fits into a single 24-hour day.

We have already taught the Apple how to do this scaling. That's what the program does. What you need to tell it is how long ago, in millions of years, an event occurred. The Apple will then tell you that, if the entire history of the earth equals 24 hours, your event occurred at a certain clock time (A.M. or P.M.).



Here are a few times to try. For others, you can find the number of years since certain things happened by looking in an encyclopedia.

Event	How Long Ago (approximately)	
First rocks cooled	3800	million years
Water formed	3000	
First life forms	570	
First fishes	400	
First insects	375	
Appalachians formed	225	
Rocky mountains formed	70	
Ice age	2	
Humans appeared on earth	0.05	

Program Listing

```
10  HOME
20  PRINT "        GEOLOGICAL/UNIVERSAL"
30  PRINT
40  PRINT "               TIME CLOCK"
50  PRINT
60  PRINT
70  PRINT "SELECT AN AGE OF THE EARTH OR"
80  PRINT "AN AGE OF THE UNIVERSE AS A"
90  PRINT "TIME SCALE. WE WILL COMPARE"
100  PRINT "THAT AGE TO A CLOCK. THE"
110  PRINT "EARLIER THE CLOCK READS, FOR"
120  PRINT "EXAMPLE 1:00 A.M., THE FURTHER"
130  PRINT "BACK IN TIME THE EVENT OCCURRED."
140  PRINT
150  PRINT
160  PRINT "TYPE A 1 FOR AN EARTH AGE OR"
170  PRINT "TYPE A 2 FOR A UNIVERSE AGE."
180  INPUT A
190  IF A = 1 THEN B = 4600
200  IF A = 2 THEN B = 1800
210  IF A > 2 THEN 160
220  PRINT
230  PRINT "HOW MANY MILLION YEARS AGO DID"
240  PRINT "THE EVENT OCCUR?"
250  INPUT Y
260  IF A = 1 AND Y > 4600 THEN  PRINT "THE EARTH DID NOT EXIST!":
     GOTO 150
270  IF A = 2 AND Y > 18000 THEN  PRINT "THE UNIVERSE DID NOT EXIS
     ": GOTO 150
280 R = 24 - 24 * Y / B
290 H =  INT (R)
300 Q = 60 * (R - H)
310 M =  INT (Q)
320 S =  INT (60 * (Q - M))
330 M$ = "A.M."
340  IF H = 12 THEN M$ = "P.M."
350  IF H > 12 THEN M$ = "P.M.":H = H - 12
360  IF H = 0 THEN H = 12
370  PRINT "THE EVENT OCCURRED AT ABOUT "
380  PRINT H;":";M;":";S;" ";M$
390  END
```

Explanation

The variables and the line-by-line explanations are given here.

a universal or geological
b full age of earth or universe (in millions of years)

y	time (in millions of years) of event
r	decimal clock time of event
h	clock hours in r
q	minutes in r
s	seconds in r
m$	AM/PM indicator

Lines 10-150. Prints the introduction and instructions.

Lines 160-180. Asks use of earth or universe clock.

Lines 190-210. Sets full-scale age of earth (b=4600 million years) or universe (18,000 million years). Asks again if a is not 1 or 2.

Lines 220-270. Accepts a value for the event time (in millions of years) and checks to make sure that your event time is not too long ago.

Line 280. Calculates y/b, the ratio of the event time to the full-scale age of the earth or universe, multiplies it by 24 to get hours-ago on the 24-hour scale, and then subtracts that from 24 to get hours-since-beginning of earth or universe.

Line 290. Takes the integer of that number to get hours (h).

Lines 300-310. Scales to noninteger part of decimal time to decimal minutes (q), then takes its integer (m).

Line 320. Calculates the second left(s) after calculating minutes.

Lines 330-350. Checks to see if the time is PM (hours 12 or greater), and sets m$ to AM or PM. If the hours are greater than 12, subtracts 12 to stay away from military time.

Line 360. If in the hour past midnight, changes to 0 to 12.

Lines 370-380. Prints out the clock time of the event.

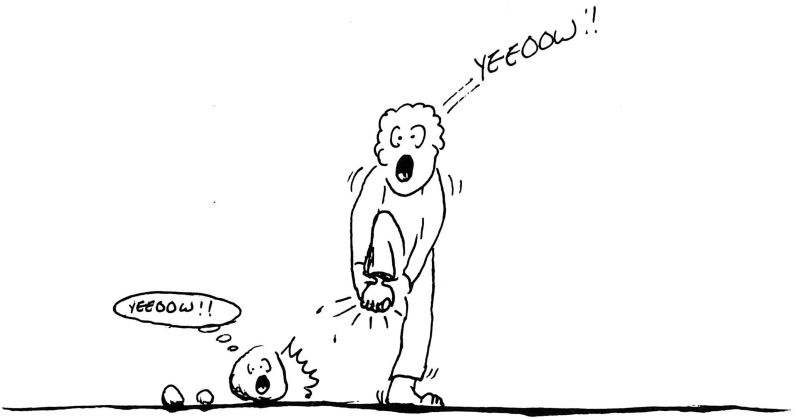
Sample Run

```
GEOLOGICAL/UNIVERSAL

      TIME CLOCK


SELECT AN AGE OF THE EARTH OR
AN AGE OF THE UNIVERSE AS A
TIME SCALE. WE WILL COMPARE
THAT AGE TO A CLOCK. THE
EARLIER THE CLOCK READS, FOR
EXAMPLE 1:00 A.M., THE FURTHER
BACK IN TIME THE EVENT OCCURRED.


TYPE A 1 FOR AN EARTH AGE OR
TYPE A 2 FOR A UNIVERSE AGE.
?1
```

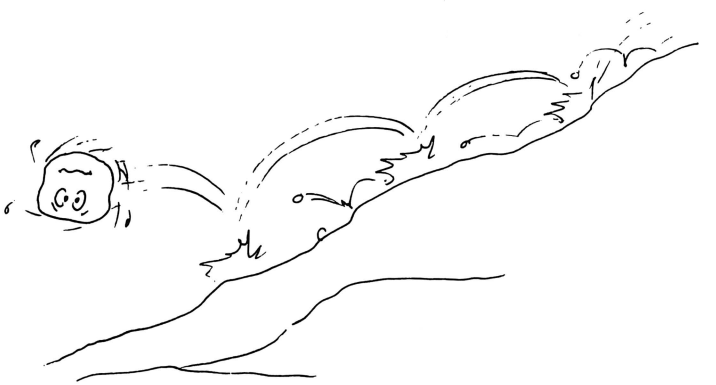
```
HOW MANY MILLION YEARS AGO DID
THE EVENT OCCUR?
?240
THE EVENT OCCURRED AT ABOUT
10:44:52 P.M.
```

ROCK IDENTIFICATION

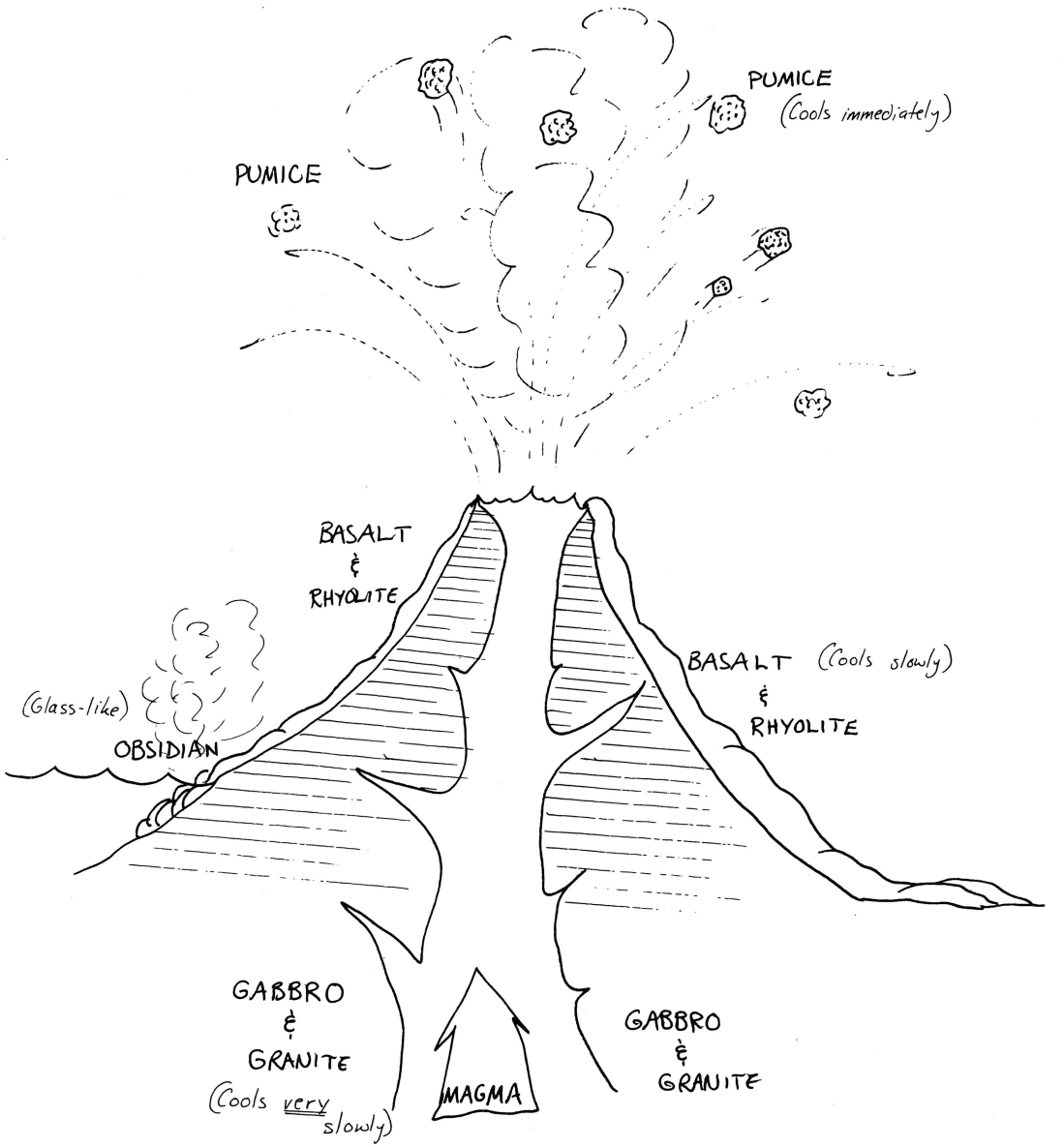
Wouldn't you like to know the life story of the next rock you stub your toe on? It might not make your toe feel any better, but you'll be able



to appreciate what the rock's been through. Some of these rocks have had a pretty rough history. Consider the possibilities: a rock can form from inside of a volcano, from being dumped at the bottom of a river, or from being crushed under miles of other rock or ice. None of these sounds too appealing.



But that's the way a rock's existence is. To get technical, the rocks that formed in volcanoes are known as *igneous* (fire-formed) rocks. If you start in a volcano, there are four possibilities for where you end up.



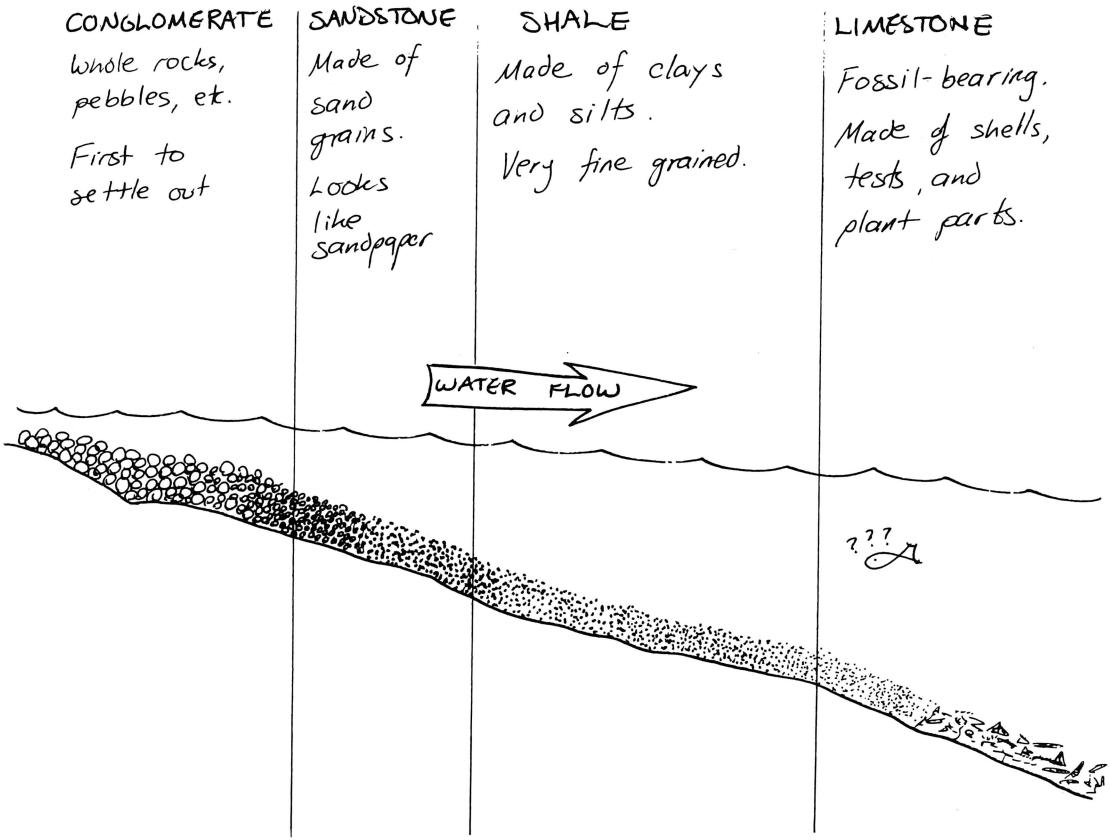
If you start as molten rock (*magma*) and are thrown into the air, and cool so quickly that your bubbles remain intact, you're known as *pumice.*

If you start as magma and cool slowly on the slopes of the volcano, you are *basalt* (if your crystals are dark colors), or *rhyolite* (if your crystals are light).

If you start as magma and make it down the slope of the volcano, only to run into some water, you cool so quickly that you become *obsidian* (volcanic glass).

If you never make it out of the volcano, and cool *very* slowly, giving your crystals plenty of time to grow, you are either *granite* (light colored) or *gabbro* (dark).

Life is different for the rocks formed in water. These are called the *sedimentary* rocks.



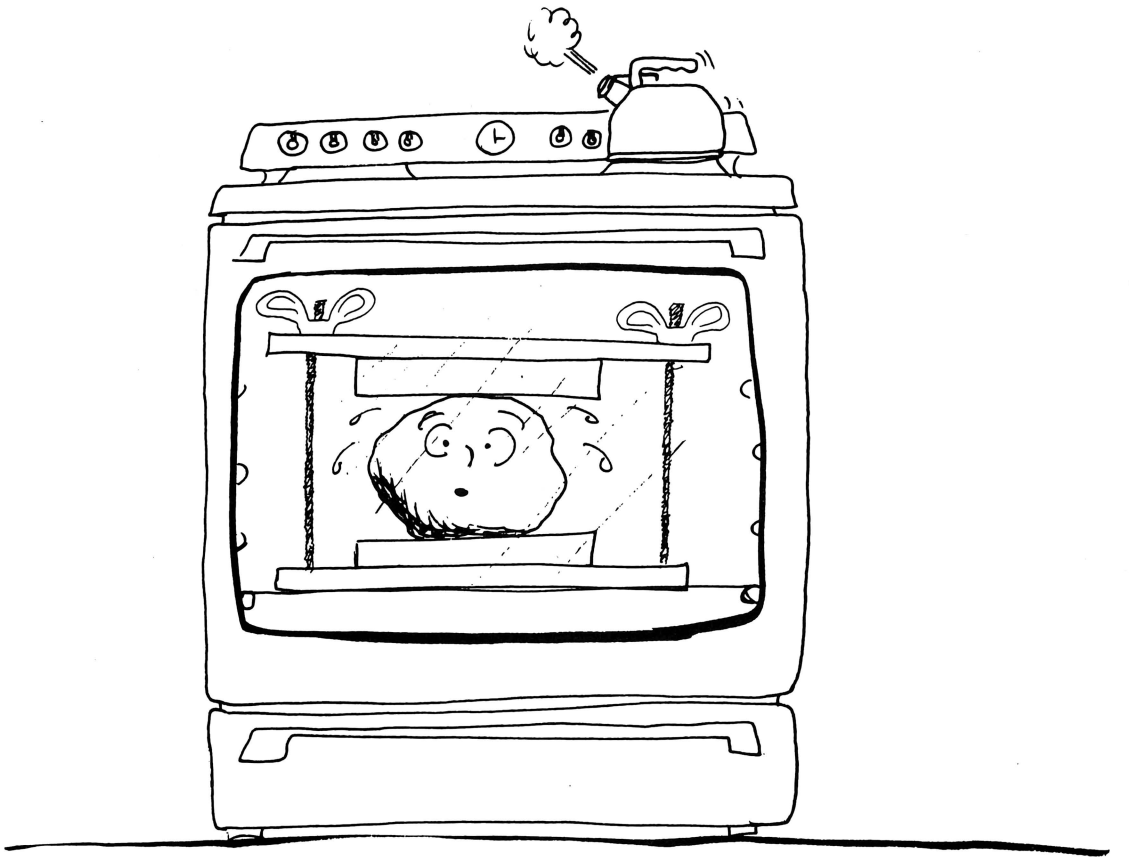
When a river slows down, the heaviest sediments fall to the river bottom first. These large pieces, including whole pebbles and stones, form a rough-grained rock known as *conglomerate.*

The next particles to fall out are the sand-sized particles, which end up as *sandstone.*

The finest-grained sediments are called clays and silts (you

probably call them mud). The rock which forms from these smallest particles is called *shale.*

There's one more variety of sedimentary rock: those which are formed from the remains of dead animals, seashells, or plant parts living in an ocean or river. This rock is called *limestone.* If some of the shells come through without being crushed, we call them *fossils.*



The third type of rock started out as one of the above, but then had something happen to it after it was first formed. These are the *metamorphic* (after-formed) rocks. The "something" that happened to them was the application of either tremendous heat, crushing pressure, or a combination of both. Needless to say, most of these rocks are found buried deep within the ground.

There are some very famous metamorphic rocks. If you heat and crush dead dinosaurs, trees, mosses, etc. for a few million years, you get coal (if it originally was mostly trees, without much decomposition). If the original material contained more water, and underwent bacterial decomposition, you'll get oil. In a manner of speaking, the energy crisis exists because we're running out of dead dinosaurs . . .

Because most metamorphic rocks used to be some other rock, we can show the relationships between the originals and the end-products.

Used To Be	Became
Granite	Gneiss
Shale	Slate
Limestone	Marble
Sandstone	Quartzite

The program that follows puts all these facts together in the form of a *key*. You need to decide whether you have an igneous, sedimentary or metamorphic rock (if you can't predict based on the above stories, take a guess).

Your Apple will then ask you some questions about your rock. Each answer will eliminate certain possibilities. The last possibility is the identity of your rock.

You can check with local high schools or colleges for nearby rock collecting areas. It's possible to put together an impressive collection from local sites. Newspapers often list rock shows and swap meets, which allow you to get rocks that are not available locally.

Happy hunting!

Program Listing

```
10  HOME
20  PRINT "     IDENTIFY THAT ROCK!"
30  PRINT
40  PRINT
50  PRINT
60  PRINT "WHAT TYPE OF ROCK DO YOU HAVE?"
70  PRINT
80  PRINT "1.  IGNEOUS"
90  PRINT
```

```
100  PRINT "2.  SEDIMENTARY"
110  PRINT
120  PRINT "3.  METAMORPHIC"
130  PRINT
140  PRINT "TYPE IN THE NUMBER OF YOUR CHOICE."
150  PRINT
160  PRINT
170  INPUT T
180  IF T > 3 THEN 130
190  ON T GOTO 200,520,850
200  HOME
210  PRINT "ENTER THE NUMBER THAT BEST"
220  PRINT "DESCRIBES YOUR IGNEOUS ROCK."
230  PRINT
240  PRINT "1.    BIG CRYSTALS WITH TWO OR"
250  PRINT "      MORE COLORS EASILY SEEN"
260  PRINT
270  PRINT "2.    SMALL CRYSTALS WITH TWO OR"
280  PRINT "      MORE COLORS BUT NOT EASILY"
290  PRINT "      SEEN"
300  PRINT
310  PRINT "3.    NO CRYSTALS AND ONLY ONE"
320  PRINT "      COLOR PRESENT"
330  INPUT I
340  IF I > 3 THEN 200
350  PRINT
360  PRINT "IS YOUR ROCK LIGHT OR DARK IN"
370  PRINT "COLOR?"
380  PRINT "ENTER 1 FOR LIGHT OR 2 FOR DARK"
390  INPUT C
400  IF C > 2 THEN 360
410  PRINT
420  PRINT "YOUR ROCK IS PROBABLY ";
430  IF C = 2 THEN 480
440  ON I GOTO 450,460,470
450  PRINT "GRANITE.": END
460  PRINT "RHYOLITE.": END
470  PRINT "PUMICE.": END
480  ON I GOTO 490,500,510
490  PRINT "GABBRO.": END
500  PRINT "BASALT.": END
510  PRINT "OBSIDIAN.": END
520  HOME
530  PRINT "ENTER THE NUMBER WHICH BEST"
540  PRINT "DESCRIBES YOUR SEDIMENTARY"
550  PRINT "ROCK'S TEXTURE."
560  PRINT
570  PRINT "1.    FEELS COARSE OR ROUGH."
580  PRINT "      PEBBLES AND ROCK FRAGMENTS"
590  PRINT "      ARE VISIBLE."
600  PRINT
```

```
610  PRINT "2.    FEELS SOMEWHAT ROUGH."
620  PRINT "      SAND-SIZE PARTICLES ARE"
630  PRINT "      PRESENT."
640  PRINT
650  PRINT "3.    FEELS SMOOTH AND FINE."
660  PRINT "      LOOKS LIKE THE ROCK IS"
670  PRINT "      MADE OF THIN LAYERS OF"
680  PRINT "      MUD."
690  PRINT
700  PRINT "4.    PARTS OF SEA ANIMALS OR"
710  PRINT "      PLANTS ARE VISIBLE."
720  PRINT "      SEASHELLS MAY BE PRESENT."
730  PRINT
740  PRINT "ENTER THE NUMBER OF YOUR CHOICE."
750  PRINT
760  INPUT S
770  IF S > 4 THEN 520
780  PRINT "YOUR ROCK IS PROBABLY ";
790  ON S GOTO 800,820,830,840
800  PRINT
810  PRINT "CONGLOMERATE.": END
820  PRINT "SANDSTONE.": END
830  PRINT "SHALE.": END
840  PRINT "LIMESTONE.": END
850  HOME
860  PRINT "ENTER THE NUMBER WHICH BEST"
870  PRINT "DESCRIBES YOUR METAMORPHIC ROCK."
880  PRINT
890  PRINT
900  PRINT "1.    MICA LAYERS ARE PRESENT IN"
910  PRINT "      THE ROCK."
920  PRINT
930  PRINT "2.    THE ROCK LOOKS LIKE IT IS"
940  PRINT "      MADE UP OF LIGHT AND"
950  PRINT "      DARK STRIPES."
960  PRINT
970  PRINT "3.    THE ROCK IS LAYERED AND"
980  PRINT "      VERY SMOOTH.  IT LOOKS"
990  PRINT "      LIKE IT IS MADE OF"
1000  PRINT "      LAYERS OF MUD."
1010  PRINT
1020  PRINT "4.    THE ROCK IS SMOOTH, NOT"
1030  PRINT "      GRAINY.  IT LOOKS LIKE"
1040  PRINT "      QUARTZ."
1050  PRINT
1060  PRINT "ENTER THE NUMBER OF YOUR CHOICE."
1070  PRINT
1080  PRINT
1090  INPUT M
1100  IF M > 4 THEN 850
1110  PRINT
```

```
1120  PRINT "YOUR ROCK IS PROBABLY ";
1130  ON M GOTO 1140,1150,1170,1190
1140  PRINT "SCHIST.": END
1150  PRINT "GNEISS."
1160  PRINT "GNEISS WAS ONCE GRANITE.": END
1170  PRINT "SLATE."
1180  PRINT "SLATE WAS ONCE SHALE.": END
1190  PRINT "QUARTZITE.": END
```

Explanation

The variable definitions are listed here. The line-by-line definitions follow.

t	number of major group
i	types of crystals (igneous)
c	light or dark color (igneous)
s	appearance of sedimentary rock
m	appearance of metamorphic rock

Lines 10-190. These lines make up the first menu of choices. Line 190 sends control to the other three major parts of the program depending on your value for t.

Lines 200-340. These lines set a value, i, which isn't used for a while. It will be used only when the color of the crystals is known, which is done in 350-430.

Lines 350-430. These lines accept another value, c, which represents the color of your rock.

Lines 440-470. The program is sent here if the crystals are light (c=1), and goes to 450, 460, or 470 depending on crystal type (1, 2, or 3).

Lines 480-510. This does the same as 440-470, but for dark (c=2) crystals.

Lines 520-780. Menu of choices for appearance of sedimentary rocks.

Lines 790-840. Sends control to correct sedimentary name.

Lines 850-1090. Menu of choices for metamorphic rock.

Lines 1100-1200. Sends control to correct metamorphic name.

Sample Run

```
IDENTIFY THAT ROCK!


WHAT TYPE OF ROCK DO YOU HAVE?
```

```
1.  IGNEOUS

2.  SEDIMENTARY

3.  METAMORPHIC

TYPE IN THE NUMBER OF YOUR CHOICE.


?1
ENTER THE NUMBER THAT BEST
DESCRIBES YOUR IGNEOUS ROCK.

1.    BIG CRYSTALS WITH TWO OR
      MORE COLORS EASILY SEEN

2.    SMALL CRYSTALS WITH TWO OR
      MORE COLORS BUT NOT EASILY
      SEEN

3.    NO CRYSTALS AND ONLY ONE
      COLOR PRESENT
?2

IS YOUR ROCK LIGHT OR DARK IN
COLOR?
ENTER 1 FOR LIGHT OR 2 FOR DARK
?1

YOUR ROCK IS PROBABLY RHYOLITE.
```

CLOUD IDENTIFICATION

When you lie under the open sky and look up at the clouds, you usually find yourself "seeing things" in them. One cloud might look like a duck, another like a dragon, yet another like Uncle Ralph's profile.

The clouds seem to be rather whimsical, changing and moving in whatever ways the winds pull them. After a while, it begins to look like a pretty disorganized show.

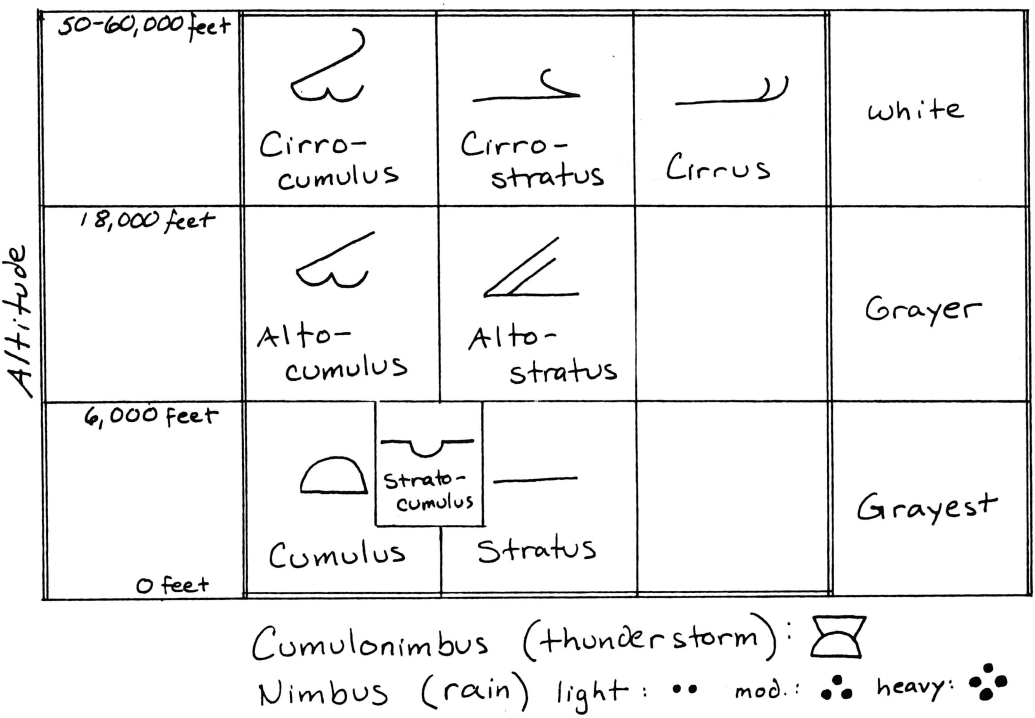
On the contrary, clouds can tell you a great deal about what's going on up there. Meteorologists use the number and type of clouds to help them understand and predict weather patterns.

If you're judging clouds by what you've seen lying out in a field, that's not fair. You've never seen rainclouds that way (we hope), and you've certainly never seen thunderclouds from that viewpoint. You might have ignored some of the more important clouds which, to the daydreaming eye, look pretty boring.

The first rule for dealing with clouds is: all clouds are shaped by the pressure, temperature, humidity, speed, and direction of the air which they are in. That list of "shapers" is exactly what a meteorologist needs to know to analyze the weather.

Meteorologists have been able to study the clouds enough to be able to put them into groups. The groups are separated according to cloud shape, size, and *altitude* (height above the ground).

Here's what the groups look like if you arrange them in a table:



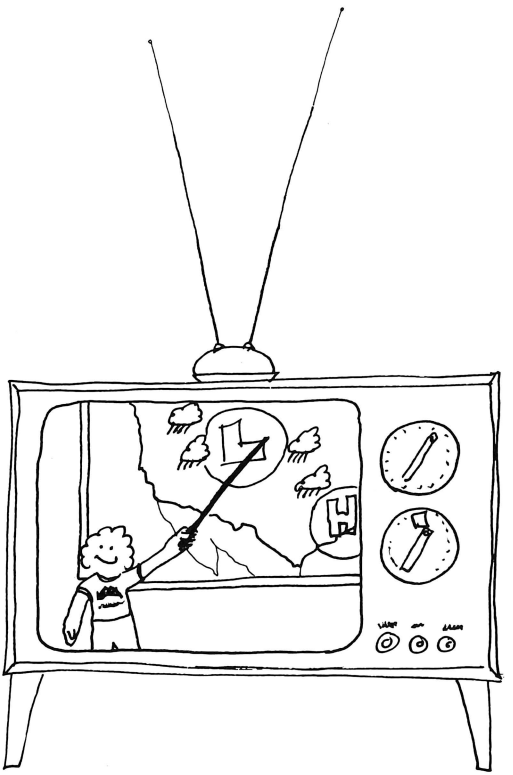
As you can see, the cloud's identity depends on what it looks like and where it is. Those two things are fairly easy to find out with the naked eye. Some meteorologists who need exact altitudes use weather balloons to measure heights, but most of this is done by estimation.

The program in this adventure will do the identifying for you. This program acts as a key, similar to the one in the last adventure on identifying rocks. When you run this program, the Apple will ask you some specific questions about the cloud(s) that interest you. A nice set-up would be to have the Apple near a window, making it easier to check on the clouds. If that's not possible, Apple's infinite patience will allow you to run to the window or outside to check.

After you run this program a few times, you'll begin to see that it is organized just like our table. The clouds' characteristics dictate what kind it is. All clouds with rounded tops are *cumulo-* something-or-other, sheet-like clouds have *stratus* in their names, and anything that has something falling from it (rain, snow, sleet, hail, etc.) gets tagged as *nimbus.*

With a little practice, you'll be able to identify clouds by sight, and use this key as a refresher or when stumped by a particularly odd-looking cloud.

If you'd like to take things one step further, and see what all of these clouds look like from the top down, check your daily newspaper's weather report. Many papers carry satellite photos of the



previous day's weather. You can check for the cloud cover in your area, and compare it to your observations.

In your next adventure, you will need to know the cloud types in order to predict the weather for the next 12 hours. So polish up your cloud identification skills and match wits with the pros!

NOTE: Please be careful when doing any activities concerning severe weather. While thunderheads are fascinating to look at, that's best done from indoors. Always keep informed of the forecast during times of dangerous weather by listening to national or local weather service reports. When they tell you to watch out, listen!

Program Listing

```
10  HOME
20  PRINT "          IDENTIFY THE CLOUDS!"
30  PRINT
40  PRINT
50  PRINT "ENTER THE NUMBER THAT BEST"
60  PRINT "DESCRIBES THE CLOUDS YOU ARE"
70  PRINT "IDENTIFYING"
80  PRINT
90  PRINT "1.    THEY COMPLETELY HIDE THE"
100  PRINT "      SUN OR MOON."
110  PRINT
120  PRINT "2.    THEY CAUSE A HALO TO FORM"
130  PRINT "      AROUND THE SUN OR MOON."
140  PRINT
150  PRINT "3.    THEY SHOW A DEFINITE"
160  PRINT "      OUTLINE OF THE SUN OR MOON."
170  PRINT
180  PRINT
190  INPUT A
200  ON A GOTO 210,420,530
210  HOME
220  PRINT "IS IT PRECIPITATING?"
230  PRINT
240  PRINT "PLEASE ENTER 1 FOR YES AND
250  PRINT "              2 FOR NO."
260  INPUT B
270  IF B > 2 THEN 240
280  IF B = 2 THEN 310
290  IF B = 1 THEN C$ = "NIMBOSTRATUS OR CUMULONIMBUS"
300  GOTO 670
310  PRINT
320  PRINT "DO THE CLOUDS HAVE ROUNDED BOTTOMS?"
330  PRINT
340  PRINT
350  PRINT "PLEASE ENTER 1 FOR YES AND"
360  PRINT "              2 FOR NO."
```

```
370  INPUT C
380  IF C > 2 THEN 350
390  IF C = 1 THEN C$ = "CUMULUS OR STRATOCUMULUS"
400  IF C = 2 THEN C$ = "STRATUS"
410  GOTO 670
420  HOME
430  PRINT "ARE THE CLOUDS SHEETLIKE OR IN LAYERS?"
440  PRINT
450  PRINT
460  PRINT "PLEASE ENTER 1 FOR YES AND"
470  PRINT "              2 FOR NO."
480  INPUT D
490  IF D > 2 THEN 460
500  IF D = 1 THEN C$ = "ALTOSTRATUS"
510  IF D = 2 THEN C$ = "ALTOCUMULUS"
520  GOTO 670
530  HOME
540  PRINT "ENTER THE NUMBER THAT BEST DESCRIBES
550  THE CLOUDS."
560  PRINT
570  PRINT "1.    LAYERED"
580  PRINT
590  PRINT "2.    BUMPY BOTTOMED"
600  PRINT
610  PRINT "3.    FEATHER-LIKE OR FIBROUS"
620  INPUT E
630  ON E GOTO 640,650,660
640 C$ = "CIRROSTRATUS": GOTO 670
650 C$ = "CIRROCUMULUS": GOTO 670
660 C$ = "CIRRUS"
670  HOME
680  PRINT " THE CLOUDS THAT YOU ARE"
690  PRINT " LOOKING AT ARE PROBABLY"
700  PRINT C$;"."
710  END
```

Explanation

The variables and program explanations follow:

a	number of major cloud type
b	number for rain/no rain
c$	name of cloud
c	number for cloud bottom description
d	number for alto types
e	number for cirro types

Lines 10-180. Asks for general description of clouds in the sky.

Lines 190-200. Sends control to the appropriate routine based on value of a.

Lines 210-290. Identifies nimbus-type clouds based on rain or no rain. b holds the value for rain/no rain.

Lines 300-410. Identifies thick clouds as cumulus or stratus based on c, the shape of the cloud bottoms.

Lines 420-520. For high clouds, selects cumulus or stratus based on sheets (d=1) or no sheets (d=2).

Lines 530-700. For well-defined, medium altitude clouds, this routine selects cirrus-type clouds on the basis of layering (e=1), rounded shape (e=2), or filament form (e=3).

Sample Run

```
          IDENTIFY THE CLOUDS!


ENTER THE NUMBER THAT BEST
DESCRIBES THE CLOUDS YOU ARE
IDENTIFYING

1.    THEY COMPLETELY HIDE THE
      SUN OR MOON.

2.    THEY CAUSE A HALO TO FORM
      AROUND THE SUN OR MOON.

3.    THEY SHOW A DEFINITE
      OUTLINE OF THE SUN OR MOON.


?1
IS IT PRECIPITATING?

PLEASE ENTER 1 FOR YES AND
             2 FOR NO.
?1
 THE CLOUDS THAT YOU ARE
 LOOKING AT ARE PROBABLY
NIMBOSTRATUS OR CUMULONIMBUS.
```

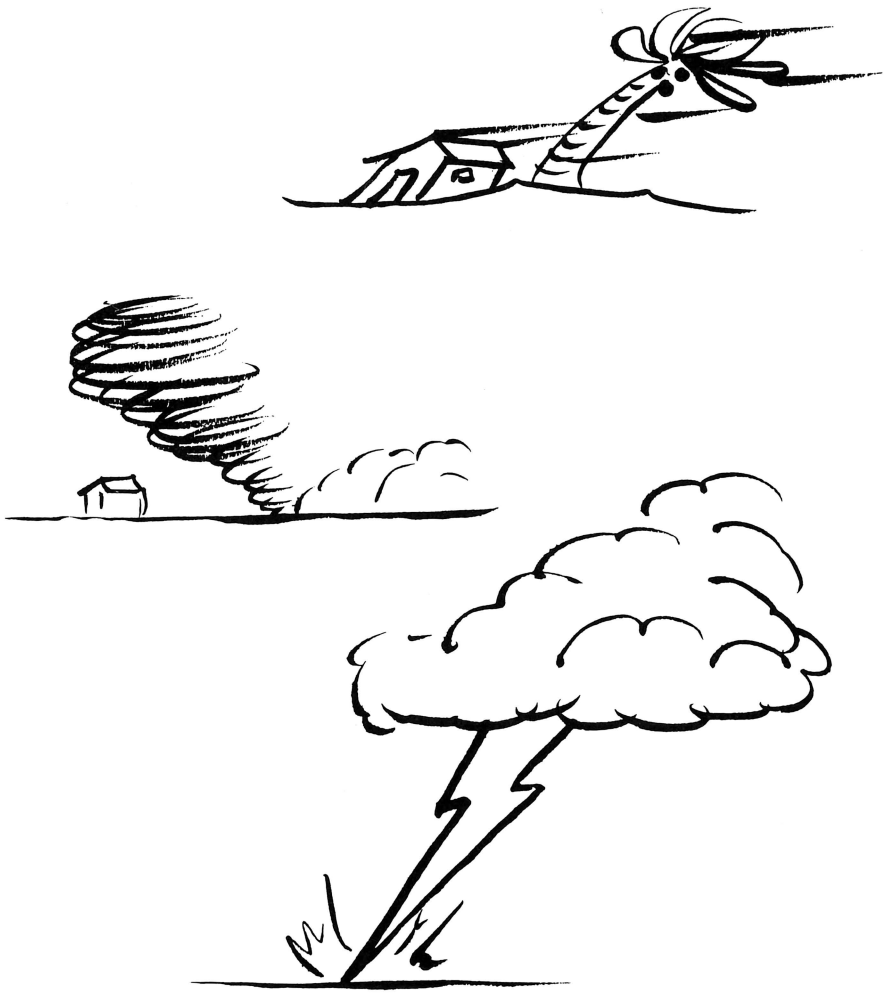
TWELVE-HOUR FORECAST

Now that you know "what's up" concerning clouds (you *did* read the last adventure, didn't you?), you can use your new-found expertise to analyze and predict the local weather.

Just as clouds seemed erratic and confusing at first, weather patterns also seem to vary wildly. If you live in certain parts of the country, such as New England or the Midwest, this can be doubly so.

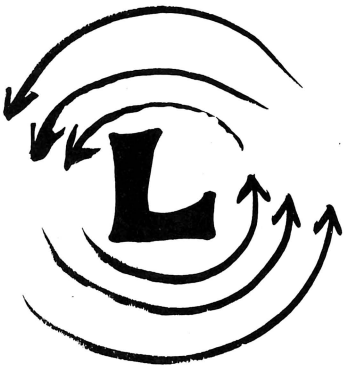
Actually, most of the time a forecaster's life is much simpler than it seems. Just as clouds have certain things in common that allow

them to be grouped, weather patterns can also be narrowed down to a few common types. Even the ones that seem to be rather disturbing—hurricanes, tropical storms, and tornadoes—can be easily identified and predicted . . . most of the time. For the sake of simplicity, we'll leave those out of this discussion.



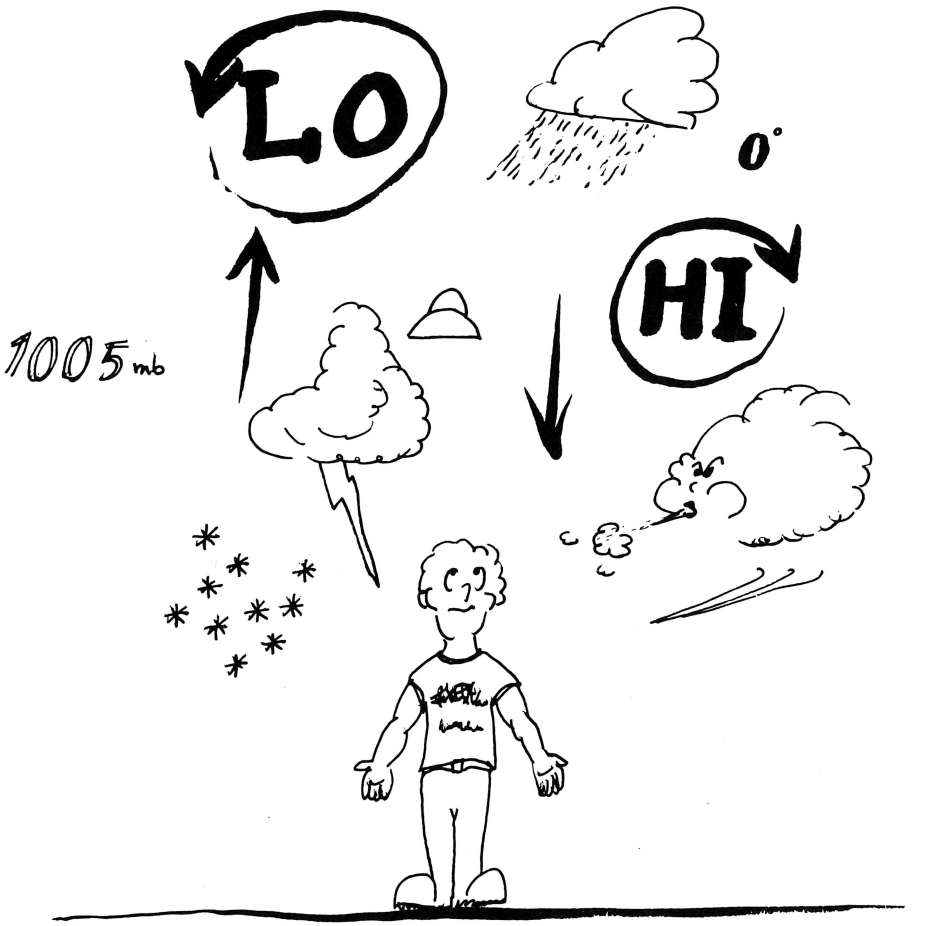
The greatest controller of weather patterns is the air's pressure. It's the relative changes in pressure that create weather, wind, and precipitation patterns. Pressure in a certain region can either be high or low (compared to what else is around it). So we speak of a *region of low pressure* (from this point on, we'll simply call one of these a LO) or a *region of high pressure* (simply called a HI).

When air begins to move *up* due to its low pressure, or *down* due to its high pressure, the spin of the earth causes it to spiral up or down rather than move straight up or down. This is known as the *Coriolis Effect*, and it's the same thing that gives a spin to water going down the drain.



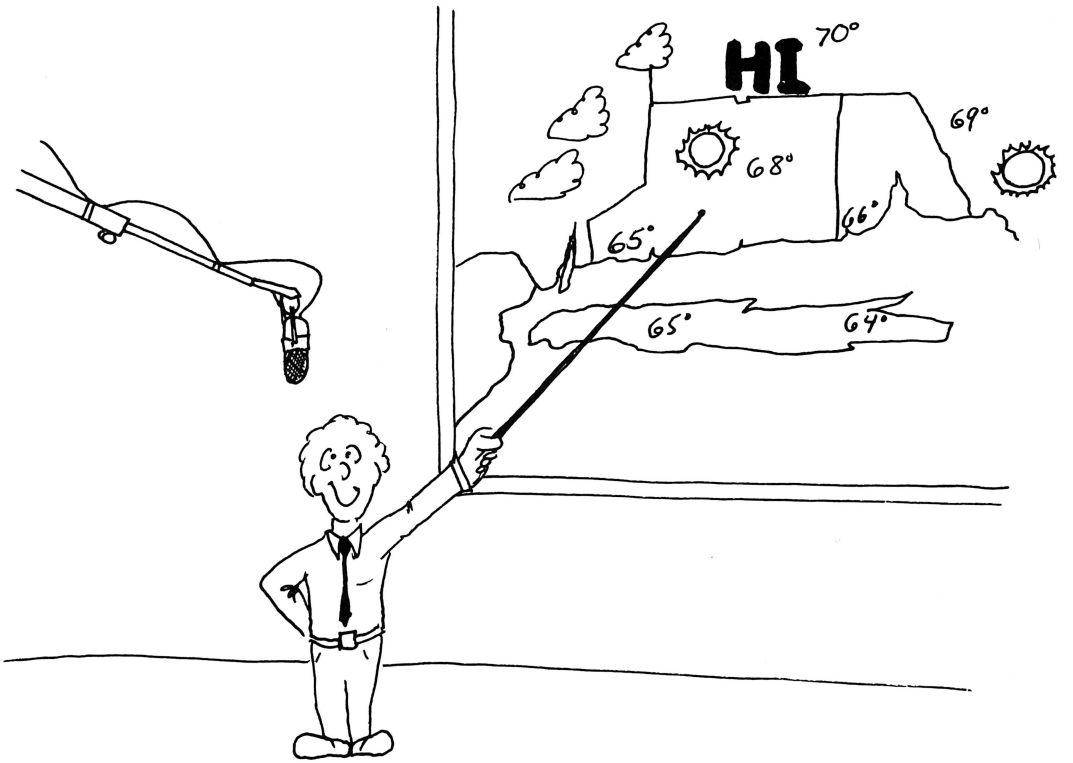
This means that we can say that in every HI, the winds end up moving *clockwise.* Conversely, the winds in a LO rotate *counter-clockwise.* Simple, no?

Well, not that simple. If the *temperature* changes, it will heat or cool the air and make it less or more likely to precipitate. Temperature will also dictate what type of precipitation you will have. *Humidity* will likewise have a say in what, if anything, will fall from the sky. And who's to say that high-altitude conditions are the same as low-altitude conditions? It seems like we're back to mass confusion, right?

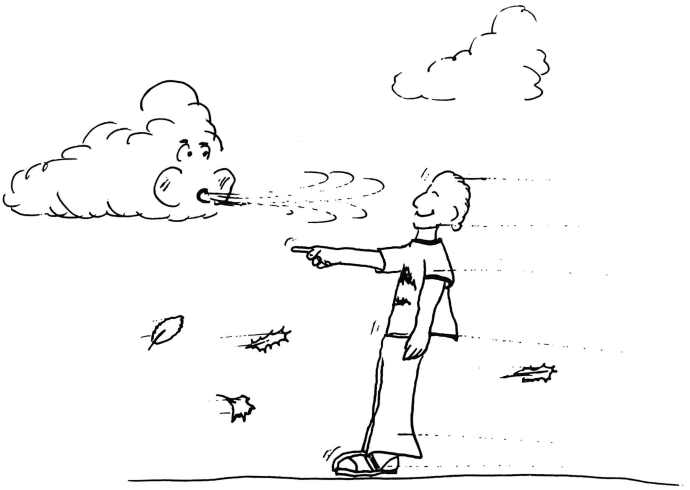


Not really. We already have a clue to all of those conditions which we just mentioned. As you saw in the last adventure, the clouds are shaped by temperature, humidity, altitude, and pressure. Therefore, if you know the clouds, you have an excellent way of knowing the conditions most of the time.

All of this knowledge enables us to predict the weather for the next 12 hours, based on the temperature, wind direction, and current conditions. The program is written so that the Apple will ask you for all of these things, and give you the forecast for the next 12 hours.



Why not longer? To give a longer forecast, you would need to know what conditions are like wherever the winds and weather are coming from. That's precisely what the National Weather Service is: a network of observers who share enough information to provide a complete picture of the weather across the country and beyond. While it's hard for you to get on this network, there's no reason why you and a handful of friends around your state or region can't set up your own network to provide your school or club with forecasts.



For observing the weather, you'll need a thermometer to measure the temperature, and some way of noting the direction which the wind is coming from. The easiest way to do this is to stand in an open area, and turn your whole body until the wind is blowing straight at your face. If you don't know the compass directions around your house, a compass will help.

With practice, you should get as good as the experts in predicting the weather. Good luck!

Program Listing

```
10  HOME
20  PRINT "          FORECAST THE WEATHER!!
30  PRINT
40  PRINT
50  PRINT "WHAT IS THE FAHRENHEIT TEMPERATURE?"
60  PRINT
70  INPUT TF
80 TC =  INT (5 / 9 * (TF - 32))
100  PRINT "THAT IS ";TC;" DEGREES CELSIUS."
120  PRINT
130  PRINT "ENTER THE NUMBER THAT BEST"
140  PRINT "DESCRIBES THE SKY."
150  PRINT
160  PRINT "1.   CLOUDY"
170  PRINT "2.   PARTLY CLOUDY"
180  PRINT "3.   CLEAR
190  INPUT S
200  IF S > 3 THEN 130
210  PRINT
220  PRINT "FROM WHAT DIRECTION IS THE WIND COMING?"
230  PRINT
240  PRINT
250  PRINT "E=90   S=180   W=270   N=360"
260  PRINT
270  PRINT "ENTER THE DIRECTION IN "
280  PRINT "DEGREES.  FOR EXAMPLE: 315"
290  PRINT "WOULD MEAN THE WIND WAS FROM"
300  PRINT "THE NORTH WEST."
310  INPUT D
320  PRINT
330  IF TF < 40 THEN P$ = "SNOW OR SLEET"
340  IF TF >  = 40 THEN P$ = "RAIN OR DRIZZLE"
350  IF D > 90 AND D < 250 THEN T1$ = "INCREASING"
360  IF D > 249 THEN T1$ = "DECREASING"
370  IF D < 91 THEN T1$ = "NEARLY CONSTANT"
380  IF S <  > 1 THEN 420
390 P1$ = "GOOD"
400  IF D < 91 THEN P1$ = "EXCELLENT"
410  GOTO 480
420  IF S <  > 2 THEN 470
430  IF D < 91 THEN P1$ = "GOOD"
440  IF D > 90 AND D < 250 THEN P1$ = "MODERATE"
450  IF D > 249 THEN P1$ = "SLIGHT"
460  GOTO 480
470 P1$ = "VERY SLIGHT"
480  FOR D = 1 TO 500: NEXT D
490  HOME
```

```
500  PRINT "THE FORECAST FOR THE NEXT 12"
510  PRINT "HOURS IS AS FOLLOWS:
520  PRINT
530  PRINT "EXPECT ";T1$;
540  PRINT " TEMPERATURES."
550  PRINT "THE PROBABILITY OF ";P$
560  PRINT "IS ";P1$;"."
570  END
```

Explanation

The variable definitions and the line-by-line descriptions are given here.

tf	Fahrenheit temperature
tc	Celsius temperature
s	number for sky cover
d	wind direction (degrees) and a wait counter
p$	expected precipitation
t1$	expected temperature direction
p1$	chances of precipitation

Lines 10-40. Prints the introduction.

Lines 50-100. Asks the Fahrenheit-degree temperature. Then, line 80 converts it to Celsius degrees.

Lines 120-200. Asks for the current cloud cover. If s doesn't equal one of the choices, it asks again.

Lines 210-310. Asks for the current wind direction in degrees, and explains the convention for wind direction.

Lines 330-340. Sets the precipitation type: rain for temperatures well above freezing, snow for those around or below.

Lines 350-370. Sets temperature direction based on wind direction: warmer if from the south, colder if from the north, constant if from east/west.

Lines 380-410. Sets chances of precipitation based on cloud cover (s=1=cloudy) and wind direction (d<91=north).

Lines 420-460. Sets chances of precipitation based on cloud cover (partly) and wind direction.

Line 470. Sets chances of precipitation based on cloud cover (clear).

Line 480. A wait counter to give your eyes a rest while watching the screen.

Lines 490-520. Header for the forecast.

Lines 530-570. Prints the results.

Sample Run

```
          FORECAST THE WEATHER!!

WHAT IS THE FAHRENHEIT TEMPERATURE?

?80
THAT IS 26 DEGREES CELSIUS.

ENTER THE NUMBER THAT BEST
DESCRIBES THE SKY.

1.    CLOUDY
2.    PARTLY CLOUDY
3.    CLEAR
?3

FROM WHAT DIRECTION IS THE WIND COMING?


E=90    S=180    W=270    N=360

ENTER THE DIRECTION IN
DEGREES.  FOR EXAMPLE: 315
WOULD MEAN THE WIND WAS FROM
THE NORTH WEST.
?230

THE FORECAST FOR THE NEXT 12
HOURS IS AS FOLLOWS:

EXPECT INCREASING TEMPERATURES.
THE PROBABILITY OF RAIN OR DRIZZLE
IS VERY SLIGHT.
```

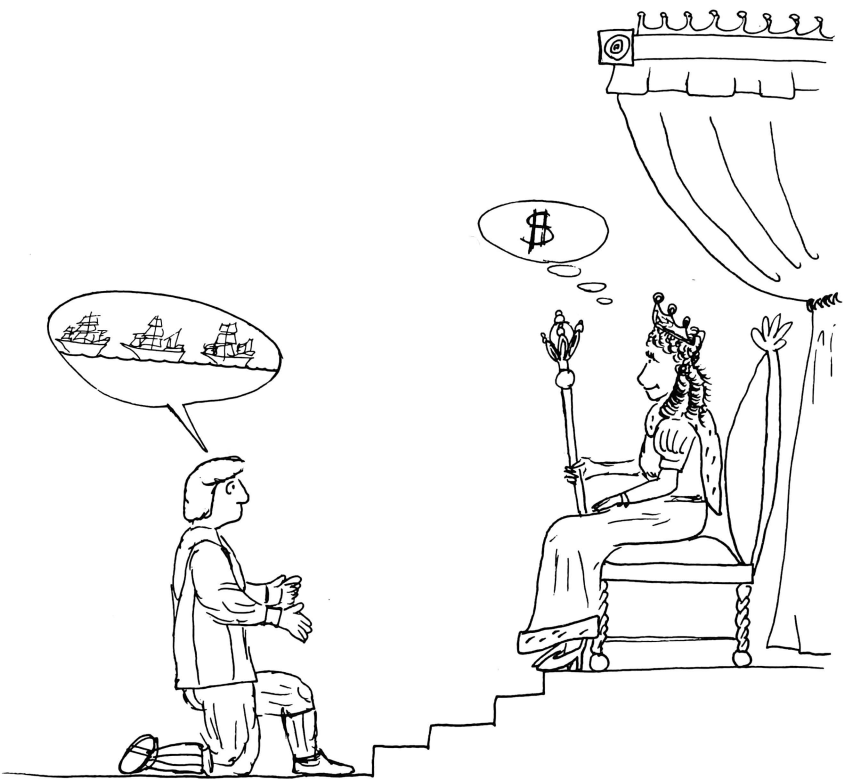
MEASURING THE EARTH'S CIRCUMFERENCE

As you might already know, for a long time people thought that the earth was flat. But certainly, you say, Magellan and his 'round-the-world voyage must have put an end to that kind of thinking!

Wrong. To this day, there exists a Flat Earth Society (a tradition with its beginnings in Greek mythology) whose members won't believe a word of this. So much for the power of logic.

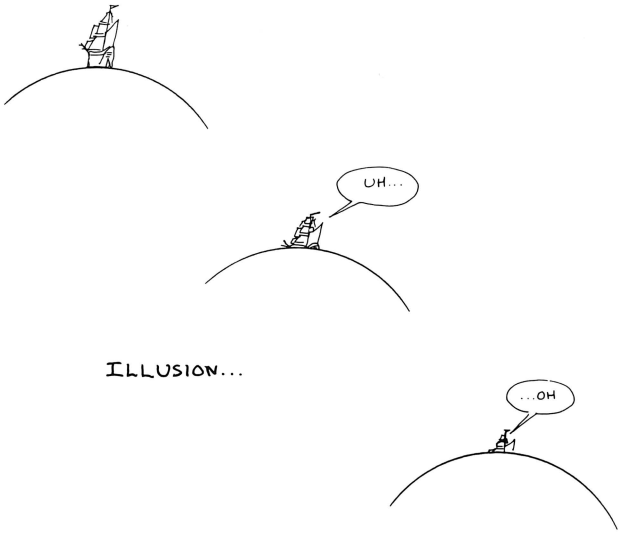
Christopher Columbus became well known for the stink he made concerning the shape of the earth. He set out to prove that the earth was a sphere and that it was indeed possible to sail a ship completely around it. In the face of many refusals by noblemen to finance such nonsense, Chris finally convinced Isabella, Queen of Spain, to pay for his experiment. In reality, he never made it com-

pletely around the earth. He never even got to India, which was always accessible from eastern Europe. Instead, he bumped into the Caribbean Islands, and decided tht he had reached the "West Indies."

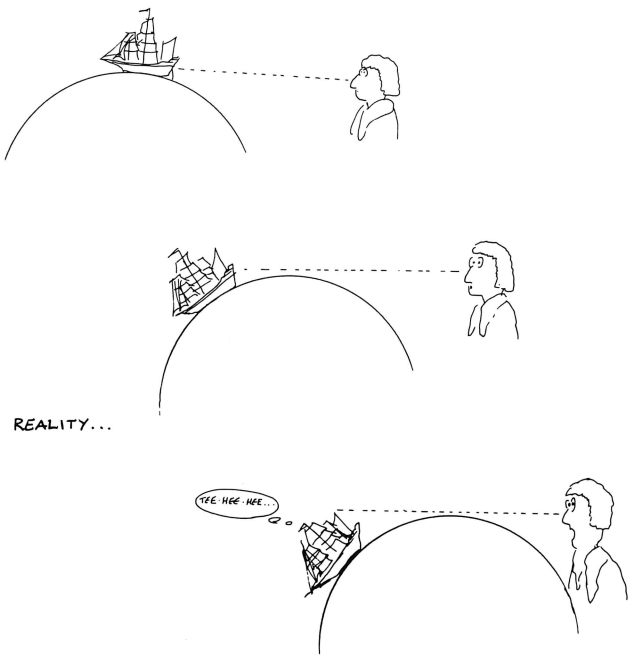


So, although he never proved his original point, it's probably a good thing that he stuck to his guns.

Back to the roundness of the earth. Early sailors who ventured out into the open sea were somewhat worried that they would fall off the edge. Supporting these fears was the observation from land that ships seemed to disappear over an edge. What they were really



seeing was the effect of the earth's curvature. Once a ship (or a vehicle on dry land) gets far enough away, the earth gets in the way of your vision, and the ship/vehicle is eclipsed by the round earth. So, as

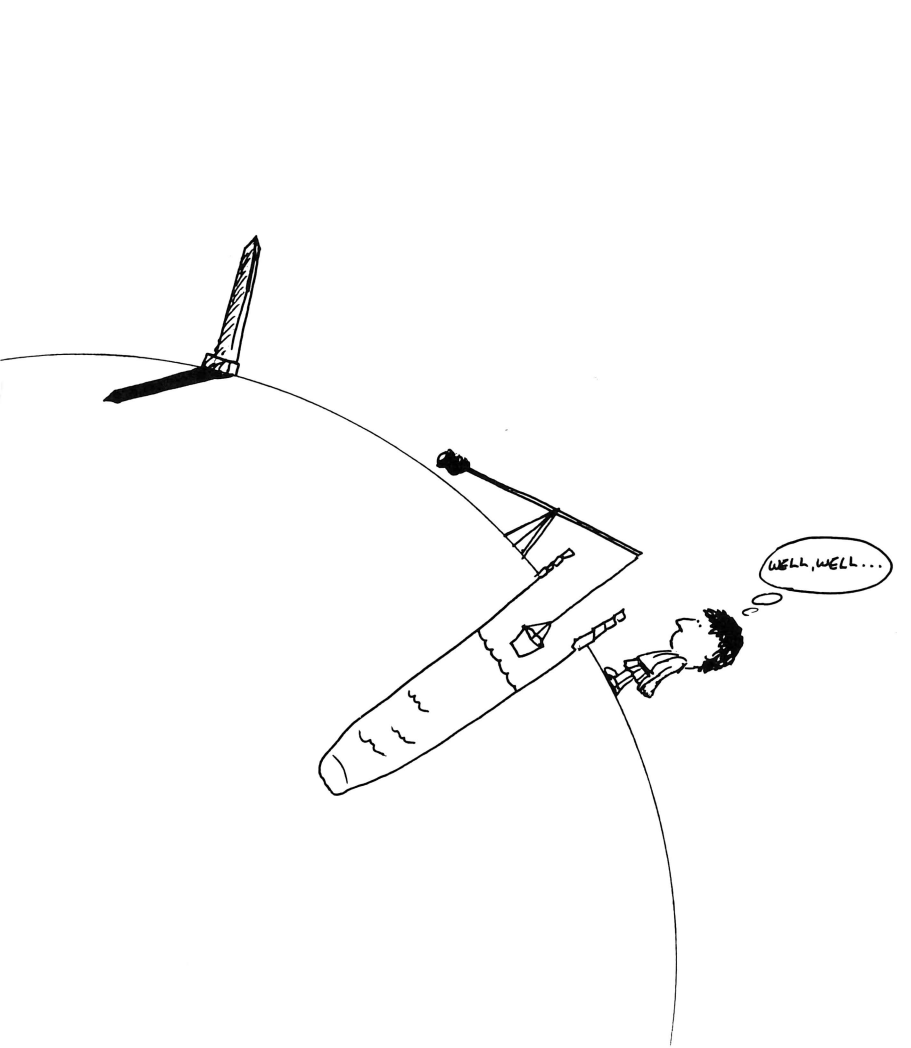


it turns out, our terrified landlubber ancestors were convinced of a flat earth by the very proof of its round shape.

This whole problem began to clear up when sailors returned to their home ports without having seen any edge. Slowly but surely, people began to form a new model for the earth's shape that would explain the disappearances: a sphere.

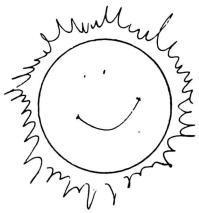
Long before Columbus, in 192 B.C., a Greek by the name of Eratosthenes came up with this idea of a round earth and a way to measure its size.

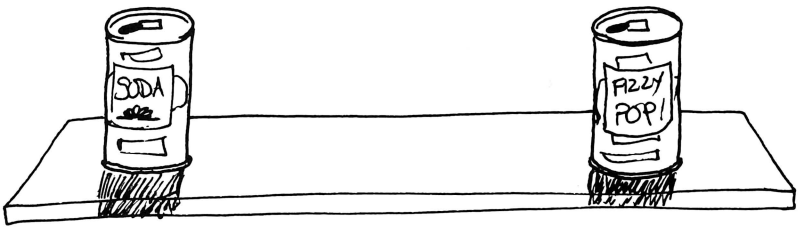
Eratosthenes was intrigued by shadows which he had heard



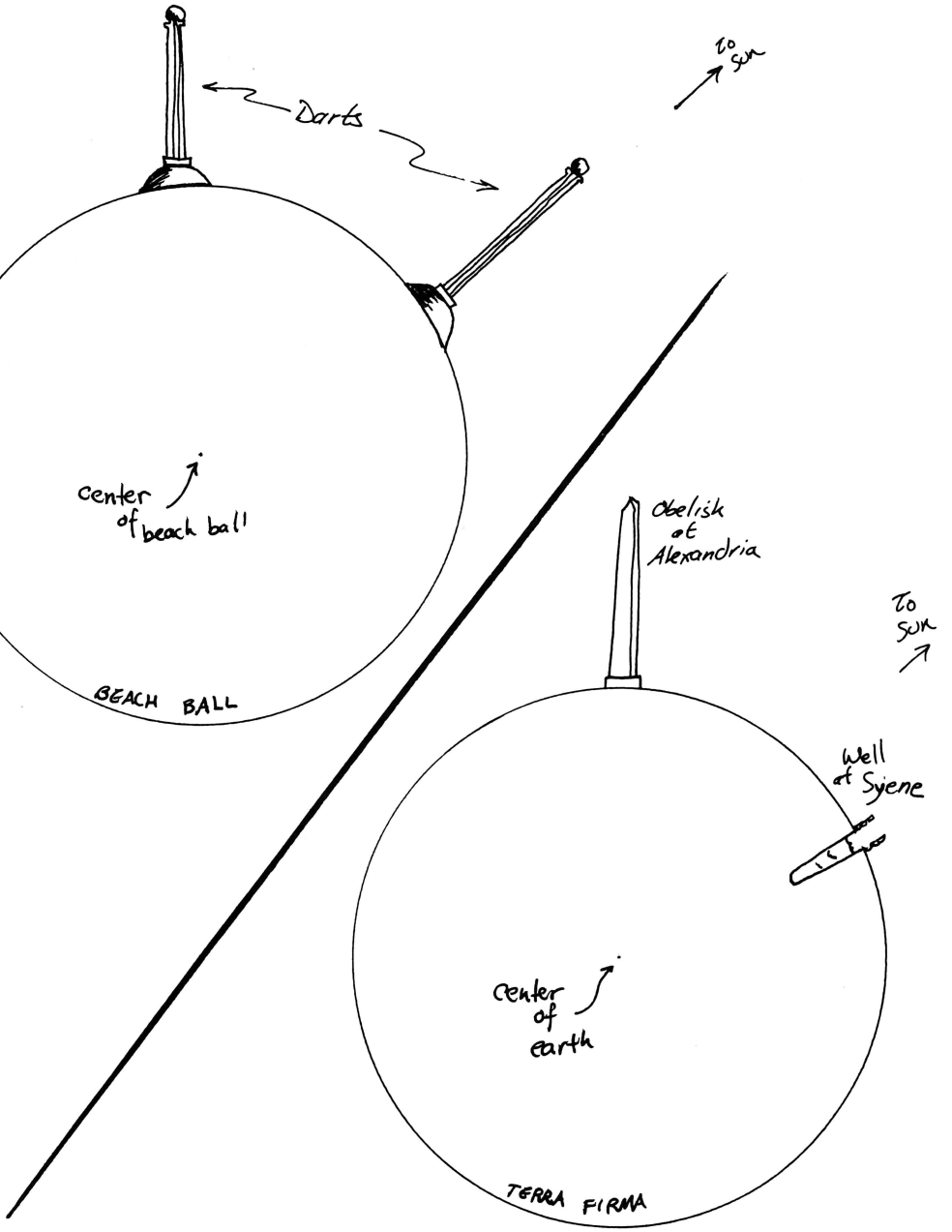
reports of. In southern Syene, Egypt (close to the equator), the noonday sun would shine straight down the shaft of a well on certain days of the year. Yet in Alexandria, 500 miles further north, there were no objects upon which the sun would shine straight down. It bothered Eratosthenes that this happened, because it couldn't be explained if the earth were flat. There simply is no way to have a vertical object cast a shadow in one place and not in another distant place, so long as both of the objects are on a flat surface.

If you don't believe it, get a long board and two soda cans. Go outside into the sun at noon and try to move the board so that only one of the cans casts a shadow. Give up?



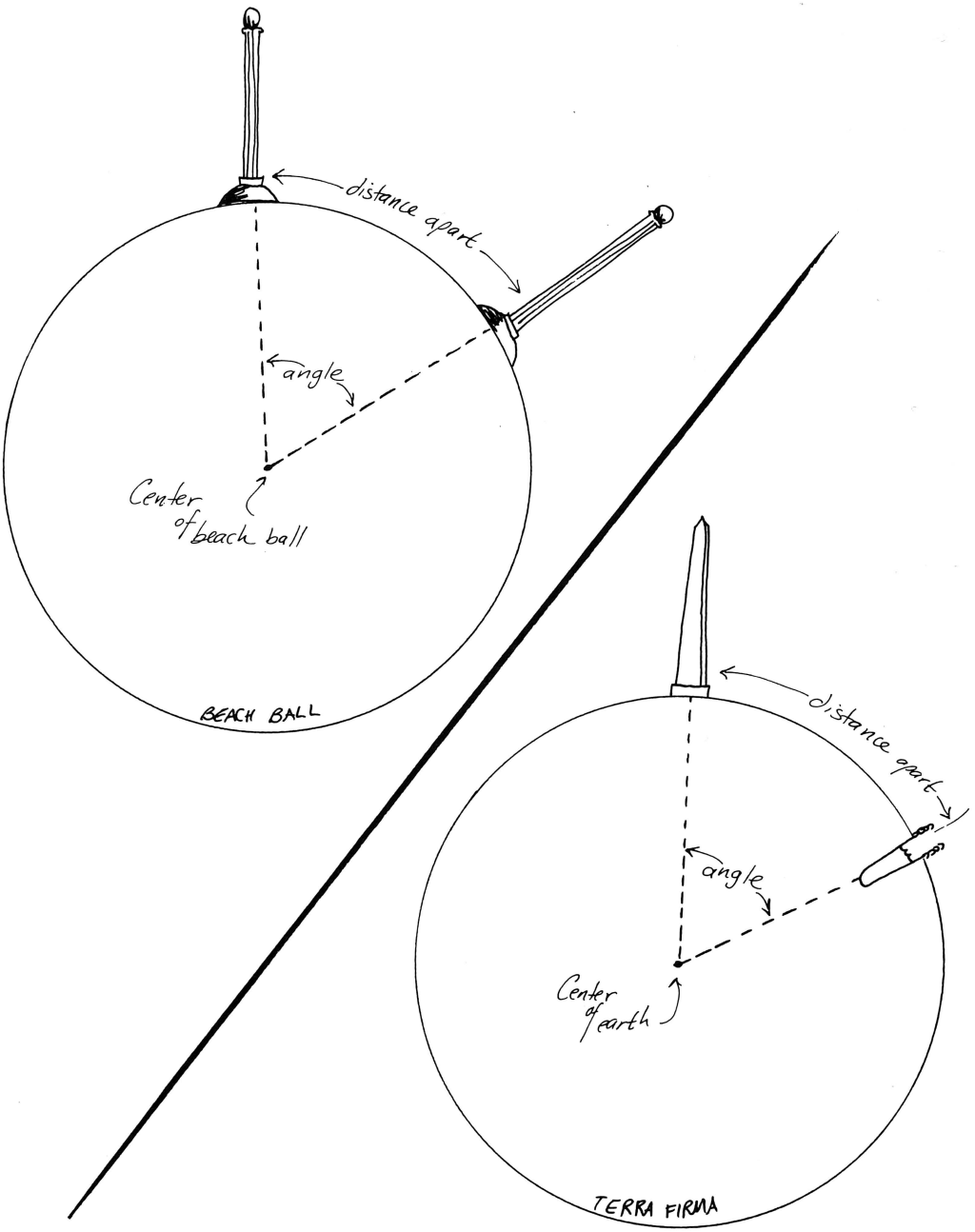


The only way this can work is if the surface isn't flat like a board, but instead is curved like a beach ball. To model this, you'll need a beach ball and some suction-cup darts from a toy gun. Plant the darts on the ball instead of the cans on the board. Now you will have some success in the sun. Point one dart straight at the sun (no shadow) and voila! The other dart has a shadow. This is just what Eratosthenes observed between the reports from Syene and Alexandria.

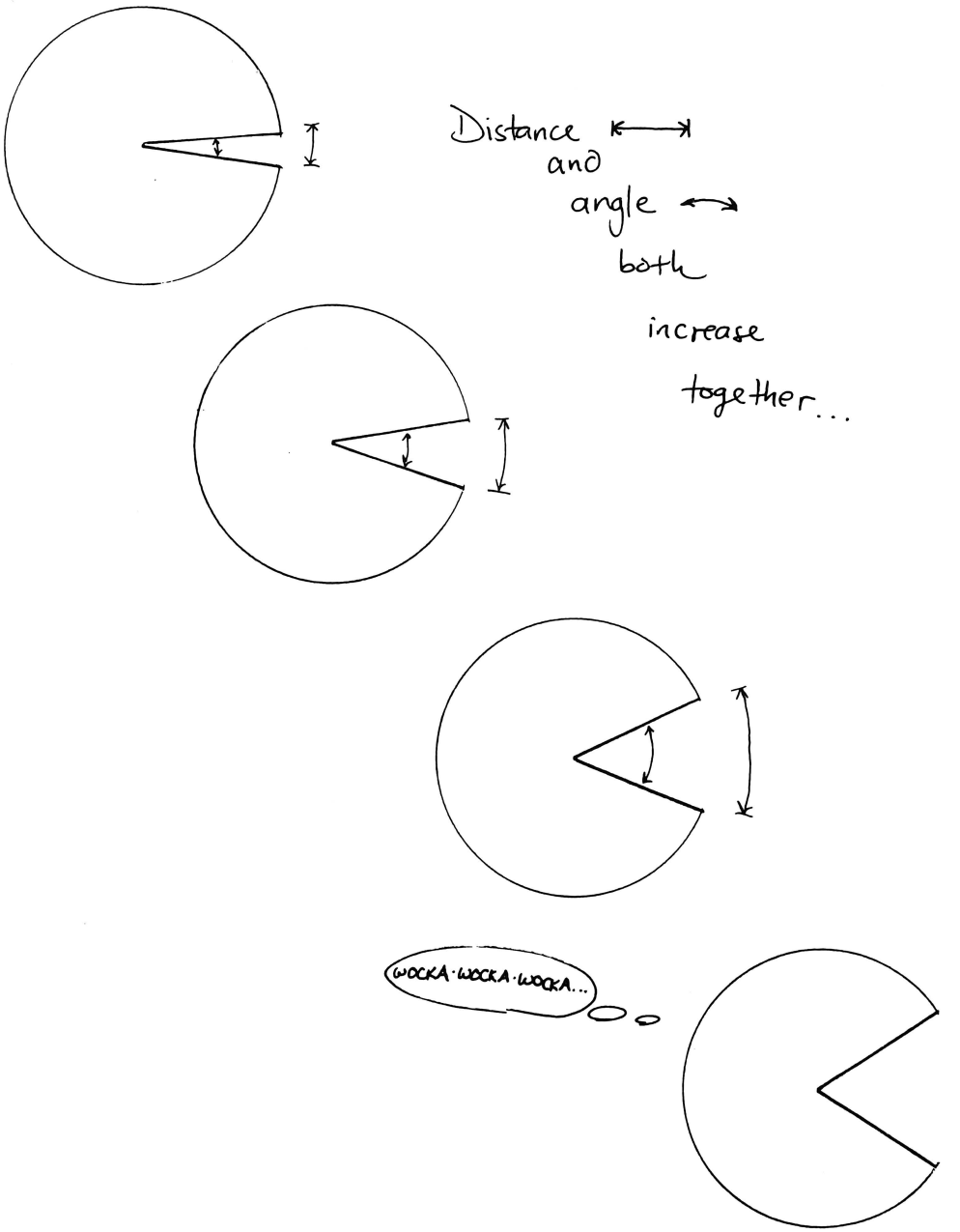


The earth must be round (like your beach ball) if the Alexandria/Syene shadows are to be explained. Furthermore, the two objects (your darts) must point to the center of this round earth, because they're vertical.

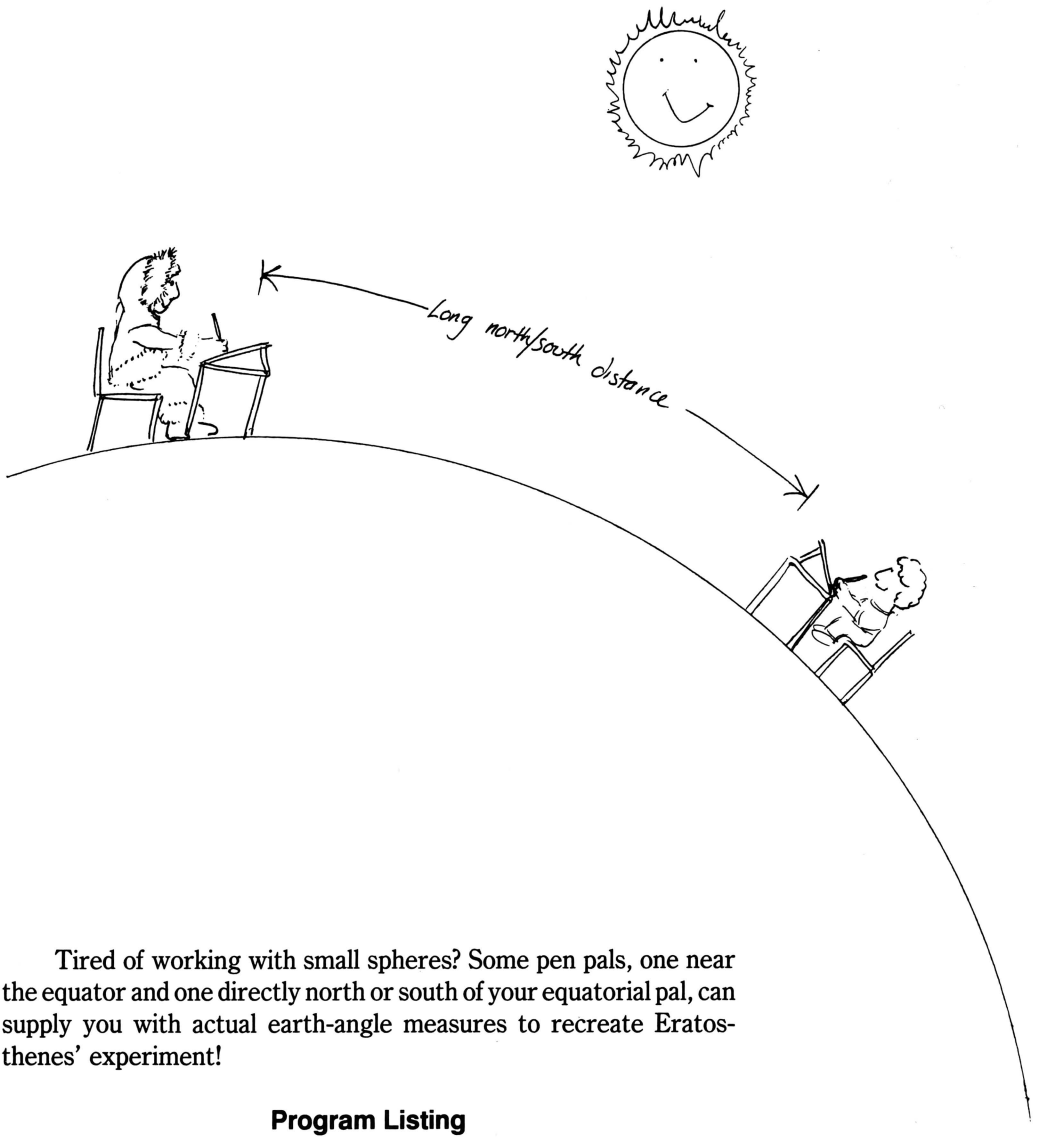
Eratosthenes knew the distance between the two sites. He also knew the angle of the shadow in Alexandria. Remembering his geom-



etry, he knew that the angle made by the two objects must relate to their distance apart in the same way that the total angle made by the earth's sphere relates to its circumference. Now he had it! All he had to do was to set up a proportion with these angles, and he would get a number for the circumference of the earth!



This computing is what the program does for you. You can easily use the darts on any smooth-surfaced ball. Orient the darts' shadows as we did above, and measure two things: the distance between the darts, and the angle of the shadow on the dart that has a shadow. The Apple will then tell you the circumference of the ball that you're working with.



Tired of working with small spheres? Some pen pals, one near the equator and one directly north or south of your equatorial pal, can supply you with actual earth-angle measures to recreate Eratosthenes' experiment!

Program Listing

```
10  HOME
20  PRINT "                MEASURE THE"
30  PRINT
40  PRINT "           EARTH'S CIRCUMFERENCE"
50  PRINT
60  PRINT
70  PRINT "BY USING THE MATERIALS"
80  PRINT "MENTIONED IN THE TEXT, WE"
90  PRINT "CAN MEASURE THE CIRCUMFERENCE"
100  PRINT "OF THE EARTH AND OTHER OBJECTS."
110  FOR D = 1 TO 10000
120  NEXT D
```

```
130  HOME
140  PRINT "WE FIRST MODEL THE EARTH BY"
150  PRINT "USING A SMALL BALL WITH TWO"
160  PRINT "DARTS ON IT. TURN THE BALL SO"
170  PRINT "THAT ONE DART CASTS NO SHADOW."
180  PRINT
190  PRINT "WHAT IS THE DISTANCE BETWEEN"
200  PRINT "THE DARTS (IN YOUR OWN UNITS)?"
210  PRINT
220  INPUT D
230  PRINT
240  PRINT "WHAT UNITS DID YOU USE?"
250  PRINT
260  INPUT U$
270  PRINT
280  PRINT "WHAT IS THE ANGLE (IN DEGREES)"
290  PRINT "FORMED BY THE DART AND THE"
300  PRINT "LINE CONNECTING THE TOP OF THE"
310  PRINT "DART TO THE END OF ITS SHADOW?"
320  PRINT
330  INPUT A
340 A = A * 3.14 / 180
350 C = 2 * 3.14 * D / A
360 C =  INT (C * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
370  PRINT
380  PRINT "THE BALL HAS A CIRCUMFERENCE"
390  PRINT "OF ABOUT ";C;" ";U$;"."
400  FOR D = 1 TO 2000
410  NEXT D
420  HOME
430  PRINT "NOW LET'S ESTIMATE THE "
440  PRINT "CIRCUMFERENCE OF THE EARTH"
450  PRINT "BY USING THE REAL THING."
460  PRINT
470  PRINT "GIVEN A TOWER THAT IS H FEET"
480  PRINT "HIGH AND D MILES AWAY (NORTH"
490  PRINT "OR SOUTH) WHICH CASTS A"
500  PRINT "SHADOW S FEET LONG WHEN YOU"
510  PRINT "CAST NO SHADOW, IT CAN BE"
520  PRINT "SHOWN THAT S/H IS ROUGHLY"
530  PRINT "EQUAL TO 2*3.14*D*H/C. SO..."
540  PRINT "C=CIRCUMFERENCE=2*3.14*D*H/S"
550  PRINT
560  PRINT "WHAT IS YOUR VALUE FOR D (MILES"
570  PRINT "NORTH OR SOUTH)?"
580  PRINT
590  INPUT D
600  PRINT
610  PRINT "WHAT IS YOUR VALUE FOR H (FEET)?"
620  INPUT H
```

```
630   PRINT
640   PRINT "WHAT IS YOUR VALUE FOR S (FEET)?"
650   PRINT
660   INPUT S
670 C = 2 * 3.14 * D * H / S
680 C =  INT (C * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
690   PRINT
700   PRINT " THE ESTIMATED CIRCUMFERENCE"
710   PRINT "OF THE EARTH IS ";C;"."
720   END
```

Explanation

The variable list is given here. The program explanation follows the variable list.

w	delay loop counter
d	distance between objects
u$	name of units of distance
a	angle of shadow
c	circumference of sphere

Lines 10-100. Prints the introduction and explanation.

Lines 110-120. A delay loop to let you read the screen.

Lines 130-180. Background information on the method of measurement.

Lines 190-250. Gathers the number of units between darts as well as the name of those units.

Lines 260-300. Gathers the measure of the angle which was made by the dart's shadow.

Line 310. Converts a degree measure of an angle to radians, which is the way the computer deals with angle measures.

Line 320. Calculates the circumference of the sphere, based on the angle and distance.

Line 330. Rounds the circumference to three decimal places.

Lines 340-380. Displays the resulting circumference in the units which you specified (u$).

Lines 390-570. Information concerning the measurement of the actual earth's circumference.

Lines 580-600. Gathers distance (d) between you and the other object in the exercise.

Lines 610-630. Gathers the height of the tower (object).

Lines 640-660. Gathers the length of the shadow (actually measuring the angle is rather difficult).

Line 670. Calculates circumference based on height, length of shadow, and distance.

Line 680. Rounds to three decimal places.

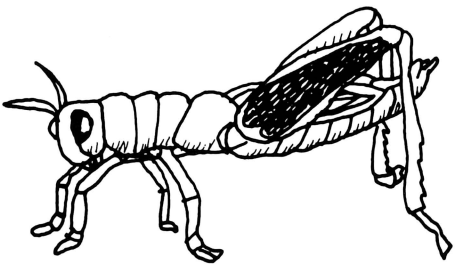
Lines 690-720. Displays your answer.

Sample Run

```
                MEASURE THE

            EARTH'S CIRCUMFERENCE


BY USING THE MATERIALS
MENTIONED IN THE TEXT, WE
CAN MEASURE THE CIRCUMFERENCE
OF THE EARTH AND OTHER OBJECTS.
WE FIRST MODEL THE EARTH BY
USING A SMALL BALL WITH TWO
DARTS ON IT. TURN THE BALL SO
THAT ONE DART CASTS NO SHADOW.

WHAT IS THE DISTANCE BETWEEN
THE DARTS (IN YOUR OWN UNITS)?

?123

WHAT UNITS DID YOU USE?

?CM

WHAT IS THE ANGLE (IN DEGREES)
FORMED BY THE DART AND THE
LINE CONNECTING THE TOP OF THE
DART TO THE END OF ITS SHADOW?

?30

THE BALL HAS A CIRCUMFERENCE
OF ABOUT 276 CM.
NOW LET'S ESTIMATE THE
CIRCUMFERENCE OF THE EARTH
BY USING THE REAL THING.

GIVEN A TOWER THAT IS H FEET
HIGH AND D MILES AWAY (NORTH
OR SOUTH) WHICH CASTS A
SHADOW S FEET LONG WHEN YOU
CAST NO SHADOW, IT CAN BE
SHOWN THAT S/H IS ROUGHLY
EQUAL TO 2*3.14*D*H/C. SO...
C=CIRCUMFERENCE=2*3.14*D*H/S

WHAT IS YOUR VALUE FOR D (MILES
NORTH OR SOUTH)?

?1.5
```

```
WHAT IS YOUR VALUE FOR H (FEET)?
?70

WHAT IS YOUR VALUE FOR S (FEET)?

?120

 THE ESTIMATED CIRCUMFERENCE
OF THE EARTH IS 5.495.
```

4

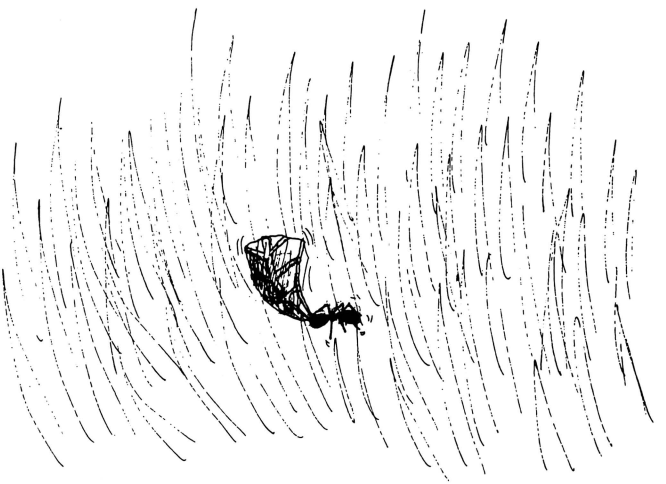


Adventures in Life Science

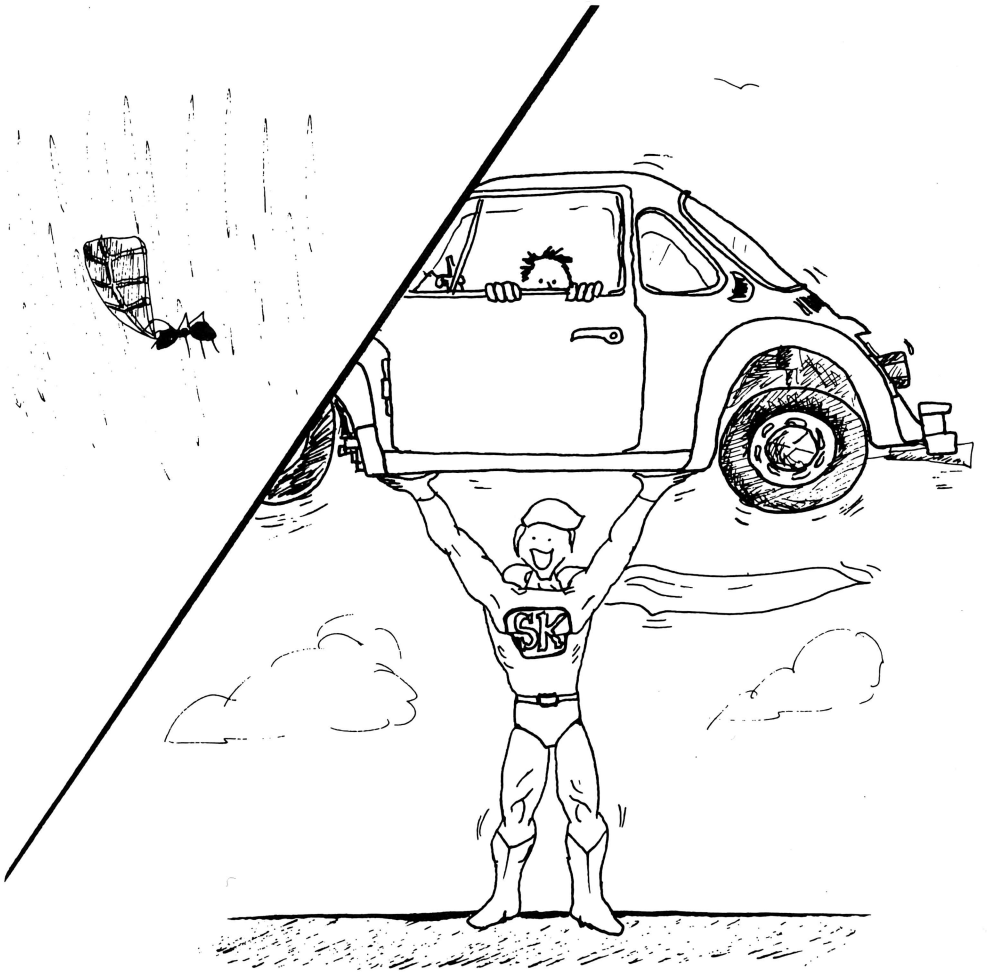
So far, we've toured the solar system, brought you back down to earth, and explored its characteristics and operation. While you're perfectly free to go back to those adventures whenever you please, we thought we'd take you for an in-depth look at the creatures which have managed to make a life on this fascinating chunk of rock. So read on, bold adventurer! Armed with your trusty Apple, you shall attempt to unravel the mysteries of the flora and fauna of planet earth. We're even willing to bet that you'll succeed!

SUPERSONIC BEES

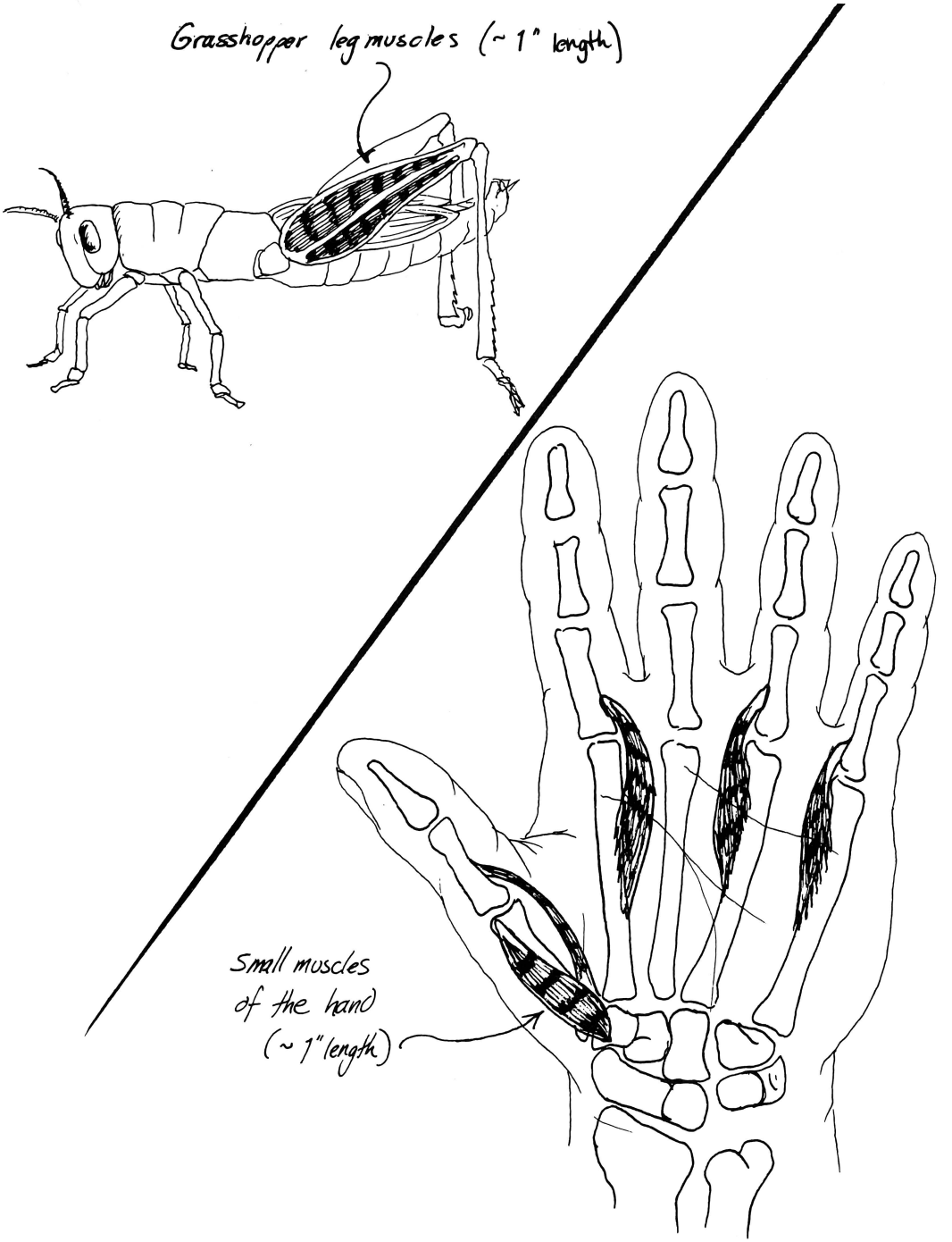
Chances are, you've sat and watched a small animal; probably an insect, perhaps an ant, and realized that this tiny beast was carrying



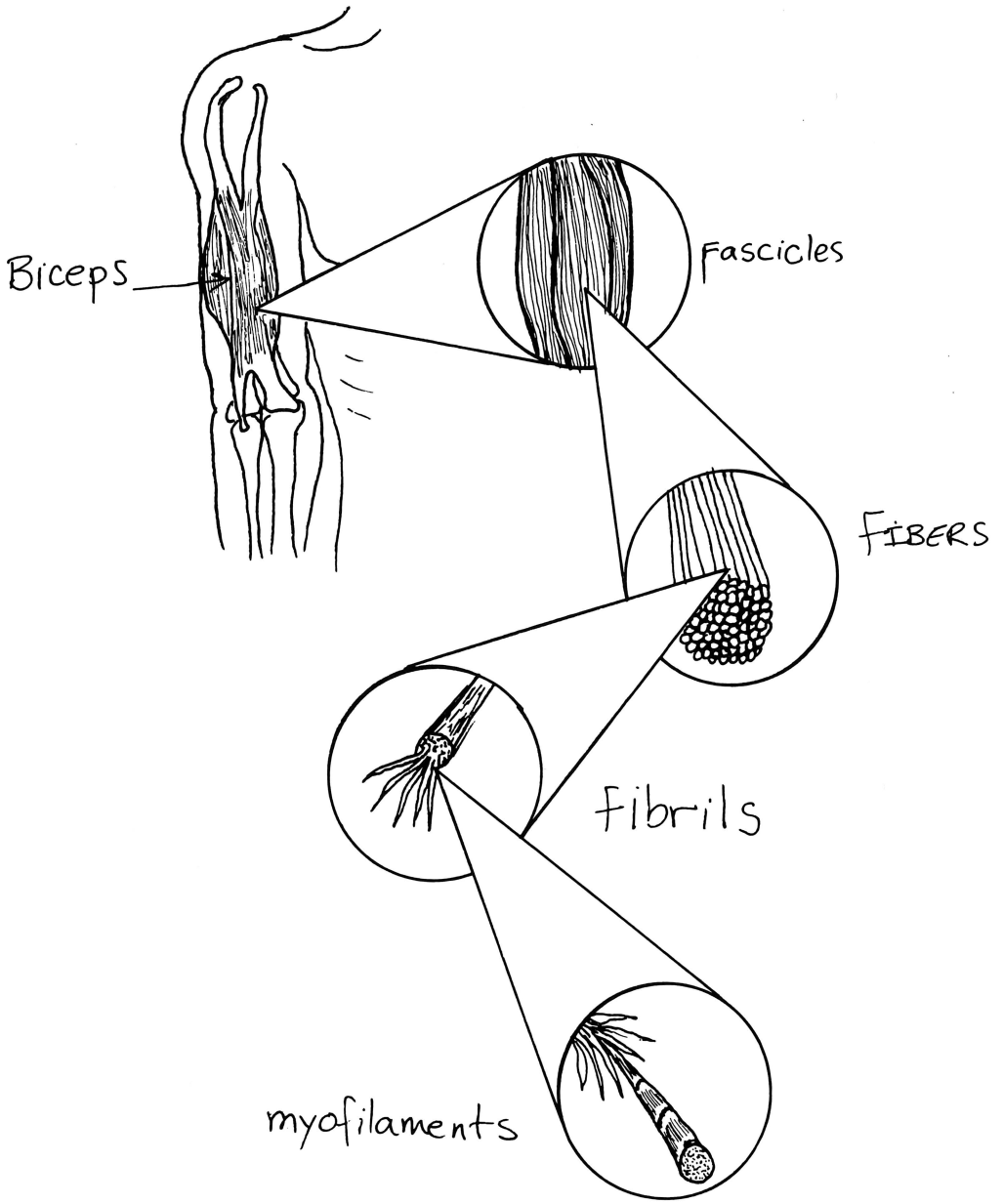
some piece of food or debris that was many times its own size. Maybe you've even imagined what it would be like to perform a similar feat, and realized that to do the sort of work that the ant was doing, you would have to lift an object like a stove or refrigerator and carry it from school to home. Do ants really put themselves through such



torture? No. Insects have very small body parts. The parts are still made out of the same atoms (carbon, hydrogen, oxygen, nitrogen, and all the rest) as you are. All the parts perform in the same way, but everything is much smaller. Their largest (leg or wing) muscles, as tiny as they are, are still muscles, about as strong as your smallest (finger or toe) muscle fibers. Therefore, while an ant can't be expected to lift you, its leg muscles *can* be expected to do the same work as your tiny finger muscles, such as move something the size of your fingertip.

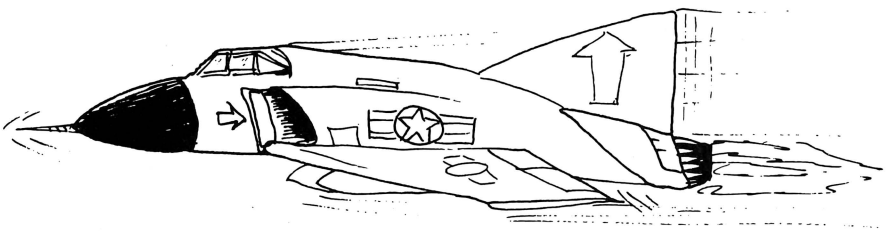


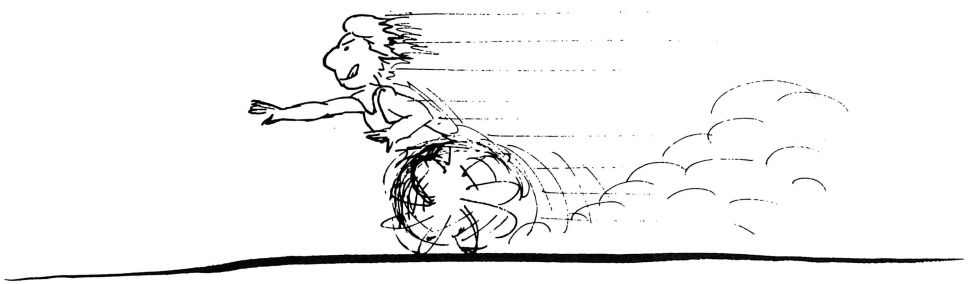
To be honest, we're the ones at a disadvantage. If we are to call on our bodies to move heavier objects, we must have many small muscle fibers working together, making for a much bigger animal.



It still remains true that a one-gram ant is perfectly capable of carrying a five-gram leaf. That's five times its own weight. And a one-centimeter honeybee can fly 20 kilometers per hour. Put in terms of its body's length, that's two million times its own length per hour. And it does all this without even breathing hard!

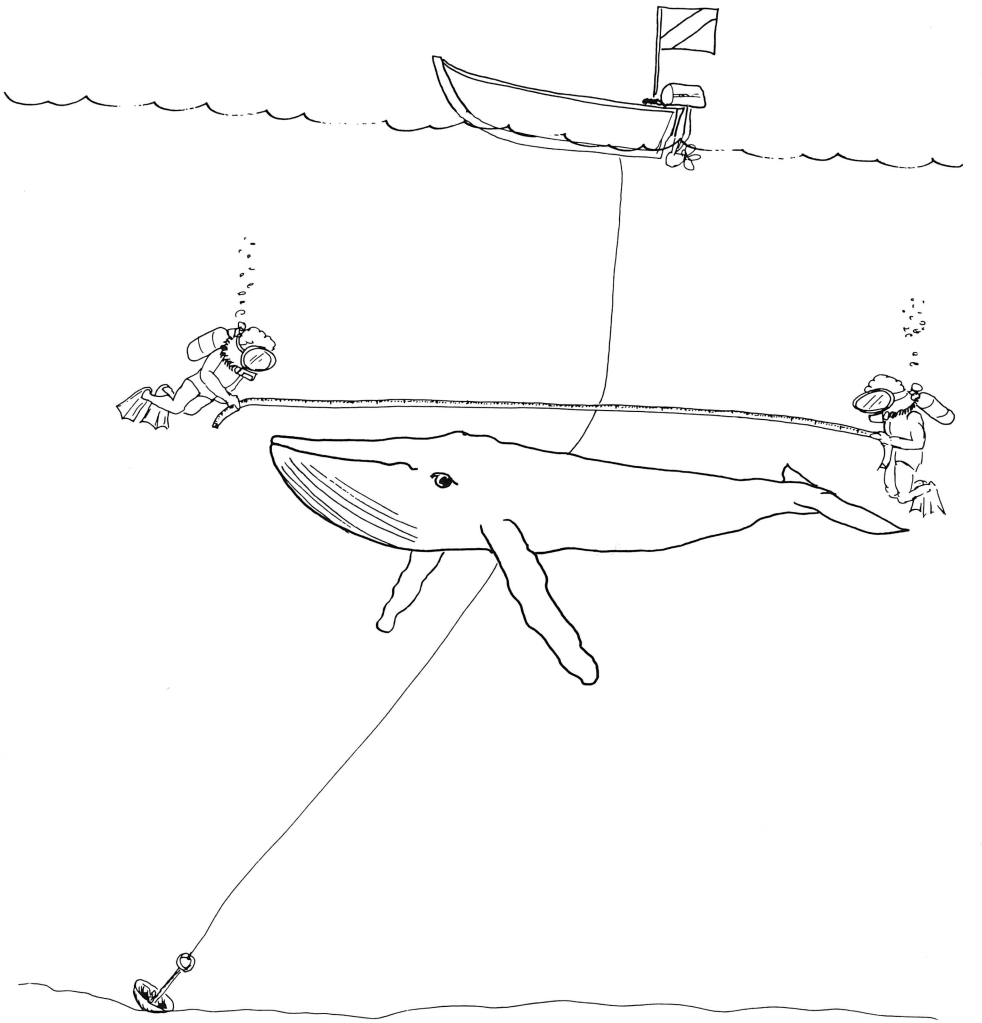
Let's see if we can find a comparison in human terms. We'll assume that the average human is five feet tall. In order for a human to cover ground as fast as our honeybee, he or she would have to go 1,894 miles in one hour! If you take 1,100 mph as the speed of sound, a human covering the same number of body-lengths-per-unit-time as a honeybee would be as fast as a jet fighter!



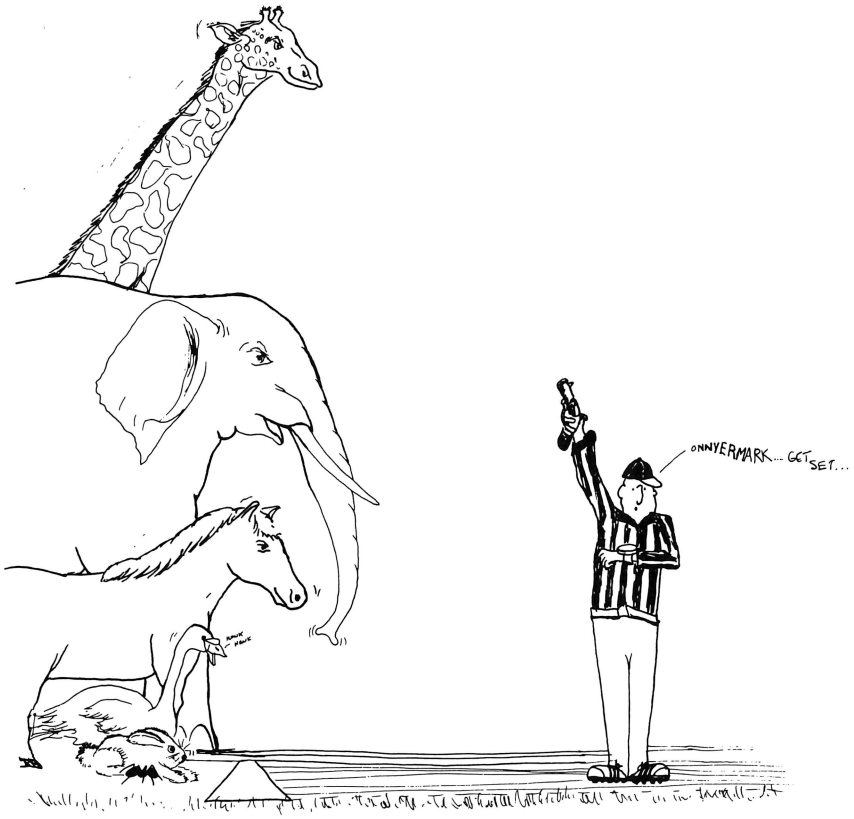


Aside from the obvious improvement in mail service, this tells us something about the marvelous efficiency built into nature. Honeybees don't need to do much more than to dart about from flower to flower (and pick up a little nectar along the way). Their bodies have evolved for that and not much else. Humans live on a larger scale, and are equipped differently.

That's the point of this program, to see the effects of scaling speeds and sizes to human terms. To do so, you will need to key in the accompanying program and give the Apple the animal's name, its body length (get a ruler or a reference book) and the distance that the



animal can cover in 15 seconds. The Apple will then tell you the actual ground-speed of that animal, and how fast it would be going if it were a 5 foot tall person.



Good luck finding out the identity of the fastest (by comparison) animal on earth! May the speediest creature (human? insect? bird? snail?) win!

Program Listing

```
10  HOME
20  PRINT "              SUPERSONIC BEES"
30  PRINT
40  PRINT
50  PRINT "WHAT KIND OF ANIMAL ARE WE TESTING?"
60  PRINT
70  INPUT A$
80  PRINT
90  PRINT "WHAT IS THE BODY LENGTH OF"
100  PRINT "THE ";A$;" (IN METERS)?"
110  INPUT L
120  PRINT
130  PRINT "WHAT DISTANCE (IN METERS) DID"
140  PRINT "THE ";A$;" COVER IN 15 SECONDS?"
```

```
150  PRINT
160  INPUT D
170 S = ((D / L) / 220) * 60
180 S =  INT (S * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
190 R = (D / 402) * 60
200 R =  INT (R * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
210  PRINT
220  PRINT "ALTHOUGH THE REAL SPEED OF"
230  PRINT "THE ";A$;" WAS ONLY"
240  PRINT R;" MPH, IF ";A$;"S WERE"
250  PRINT "OUR SIZE, THEIR SPEED WOULD BE"
260  PRINT S;" MPH!!!"
270  END
```

Explanation

The following section contains the variable descriptions and the line-by-line program description.

a$	animal name
l	a$'s body length (in meters)
d	distance covered by a$ in 15 seconds
s	distance traveled divided by 220 (body lengths per mile divided by the number of 15 seconds per minute) times 60 (minutes per hour) = scaled speed
r	real ground-speed in miles per hour (= meters per 15 sec, divided by the inverse of 15 seconds per minute times miles per meter, times minutes per hour)

Lines 10-40. Prints the introduction.

Lines 50-80. Asks the name of the animal.

Lines 90-120. Asks the body length of the animal (this must be in meters, so a one-centimeter insect is .01, a three-foot-long tortoise would be 1, etc.).

Lines 130-160. Asks the distance which you saw this animal cover in 15 seconds (so that you can use direct observations).

Lines 170-180. Converts meters per 15 seconds to a multiple of human-body-lengths-per-mile-per-minute (220), then multiplies by 60 for one hour's time. Line 180 rounds this number to three decimal places.

Lines 190-200. Converts distance-per-15-seconds to ground speed in miles per hour. Line 200 rounds to three places.

Lines 210-270. Prints these two measures, using the name of the animal.

Sample Run

```
                SUPERSONIC BEES

WHAT KIND OF ANIMAL ARE WE TESTING?

?ANT

WHAT IS THE BODY LENGTH OF
THE ANT (IN METERS)?
?.01

WHAT DISTANCE (IN METERS) DID
THE ANT COVER IN 15 SECONDS?

?3

ALTHOUGH THE REAL SPEED OF
THE ANT WAS ONLY
.448 MPH, IF ANTS WERE
OUR SIZE, THEIR SPEED WOULD BE
81.818 MPH!!!
```

EVERGREEN KEY (HOW TO UNLOCK A HEMLOCK)

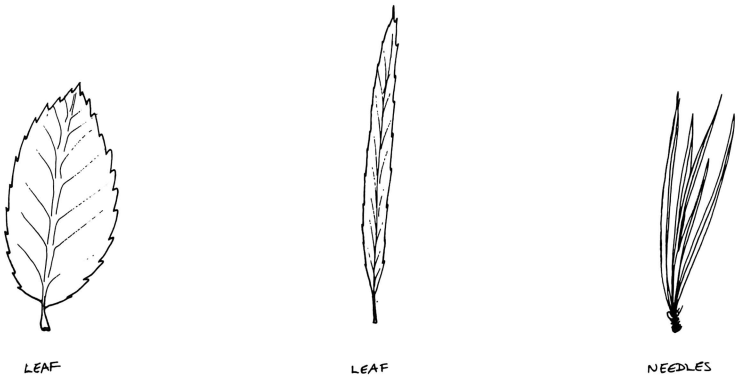
Some trees lose the use of their leaves once per year. These *deciduous* trees are the ones whose leaves turn brilliant colors in the fall and drop off of the trees. (Where do you think the term "fall" came from?) The reason for this drastic change is that the leaves are

thin-walled and don't have very much sugar in them. They would never survive the winter without damaging the tree due to freezing. So nature has provided for the tree's survival in this fashion.

But there's always more than one way to skin a cat. Or in this case, to save a tree. Some trees have evolved leaves that have tough skins and high sugar contents, and do perfectly fine, all winter long.

Because these trees aren't in danger of freezing, they don't need to lose their leaves in the winter. (They *do* lose leaves, but it happens every two to 14 years, depending on the species.) Because they stay green all year through, they are known as *evergreens.* Pine trees are evergreens. So are spruces, hemlocks, and cedars, to name a few.

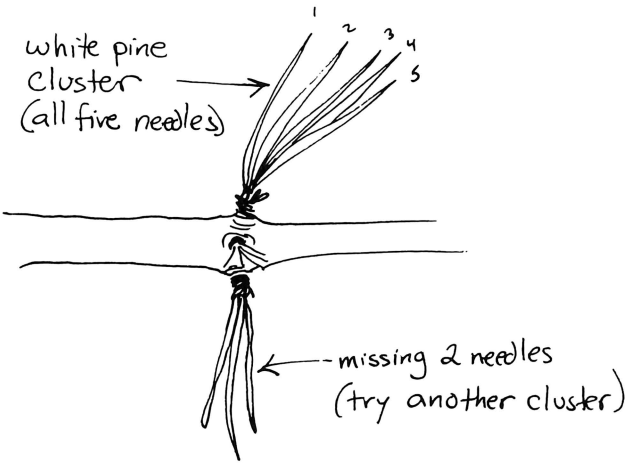
If you've ever had to deal with any of these before, you might have felt that the word "leaf" isn't the right one to use. Most evergreens feel (ouch!) like they have needles where the leaves ought to



be. In fact, the common term for evergreen leaves is needles, and that's how the Apple will refer to them in this program.

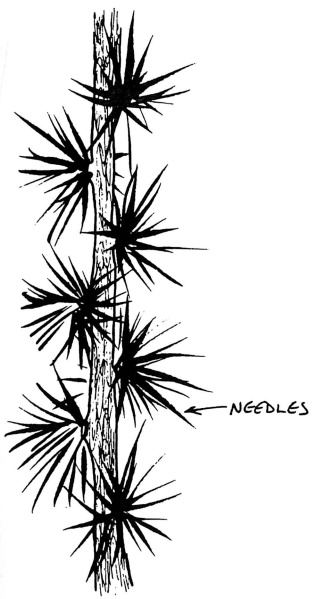
To unlock the identity of the various evergreens, you will need to know certain things about the needles that you've collected. You haven't collected any? Well, unless you live in the desert, there's an evergreen in the closest yard or park. That's the beauty of them — they're available all year long! The program will want to know the number, shape and size of the needles that you're investigating.

A few notes are necessary concerning how botanists (plant scientists) deal with needles and leaves. When the program asks you to count the number of leaves in a cluster, it means the number of



needles that come out from a single point of attachment. Although this in itself is an easy way to identify most of the pines, do look carefully if you think you have a pine. It is also possible that individual clusters have lost a needle or two, so use the highest number that you find in the clusters on any branch.

One last thing: if you're doing this during the spring or summer, there's one tree which might defy all attempts to identify it. It's called the *larch* or *tamarack*. This tree is most common in the north, and has the maddening role of being a deciduous (leaf-losing) tree that also has needles! The drawing should help you to identify this distinctive tree.



TAMARACK
BRANCH
(Larix species)

Common Name	Scientific Name
Pine	Pinus
Cedar	Cupressis
Hemlock	Tsuga
Juniper	Juniperis
Spruce	Picea

Program Listing

```
10  HOME
20  PRINT "                    EVERGREEN KEY"
30  PRINT
40  PRINT
50  PRINT "CHOOSE THE DESCRIPTION WHICH"
60  PRINT "BEST FITS YOUR TREE'S NEEDLES."
70  PRINT
80  PRINT
90  PRINT "1.  SHORT AND FLAT WITH WHITE"
100  PRINT "    UNDERSIDES"
110  PRINT
120  PRINT "2.  LONG, THIN AND SMOOTH"
130  PRINT
140  PRINT "3.  TIGHTLY CLUSTERED, PRICKLY"
150  PRINT "    AND SCALE-LIKE"
160  PRINT
170  PRINT "4.  SHORT, THICK AND SHARP "
180  PRINT
190  PRINT
200  PRINT "TYPE IN THE NUMBER OF YOUR CHOICE."
210  PRINT
220  PRINT
230  INPUT C
240  PRINT
250  HOME
260  PRINT "THE TYPE OF TREE"
265  PRINT "YOU ARE KEYING IS A ";
270  ON C GOTO 280,300,510,540
280  PRINT "HEMLOCK."
290  PRINT "INDIANS USED THIS TREE TO MAKE TEA.": END
300  PRINT " PINE."
310  PRINT
320  PRINT
330  PRINT "CHOOSE THE DESCRIPTION WHICH "
340  PRINT "BEST FITS THE PINE NEEDLE."
350  PRINT
360  PRINT "1.  2 NEEDLES IN A CLUSTER"
370  PRINT
380  PRINT "2.  3 NEEDLES IN A CLUSTER"
390  PRINT
400  PRINT "3.  5 NEEDLES IN A CLUSTER"
410  PRINT
420  PRINT "TYPE IN THE NUMBER OF YOUR CHOICE."
430  PRINT
440  PRINT
450  INPUT N
460  PRINT "THE TYPE OF PINE"
465  PRINT "YOU ARE KEYING IS A ";
470  ON N GOTO 480,490,500
```

```
480   PRINT "RED PINE.": END
490   PRINT "PITCH PINE.": END
500   PRINT "WHITE PINE.": END
510   PRINT "CEDAR."
520   PRINT "CEDAR SHAVINGS MAKE GOOD"
530   PRINT "HAMSTER BEDDING.": END
540   PRINT "SPRUCE."
550   PRINT "SPRUCES MAKE GOOD CHRISTMAS"
560   PRINT "TREES.": END
```

Explanation

The variable list and program descriptions are given here.

c Choice for first menu
n Number of pine needles

Lines 10-270. These lines set up the menu of needle types which is the first set of identifiers for the tree which you are keying. Line 230 accepts your choice, while line 270 sends the computer to the line which will do some further identification. The commands ON...GOTO send control to each of the named lines (if c=1, it goes to line 280, if c=2 it goes to 300, etc.). Keep in mind that you have to put in the number of each choice, not the word or name.

Lines 280-290. These lines identify the hemlock tree, of which there is only one distinct variety.

Lines 300-500. This is a menu for the pines (you decided that you had a pine back in line 230). It too uses "ON...GOTO" to send the program control to the correct message.

Lines 510-530. Message for cedars.

Lines 540-560. Messages for spruces.

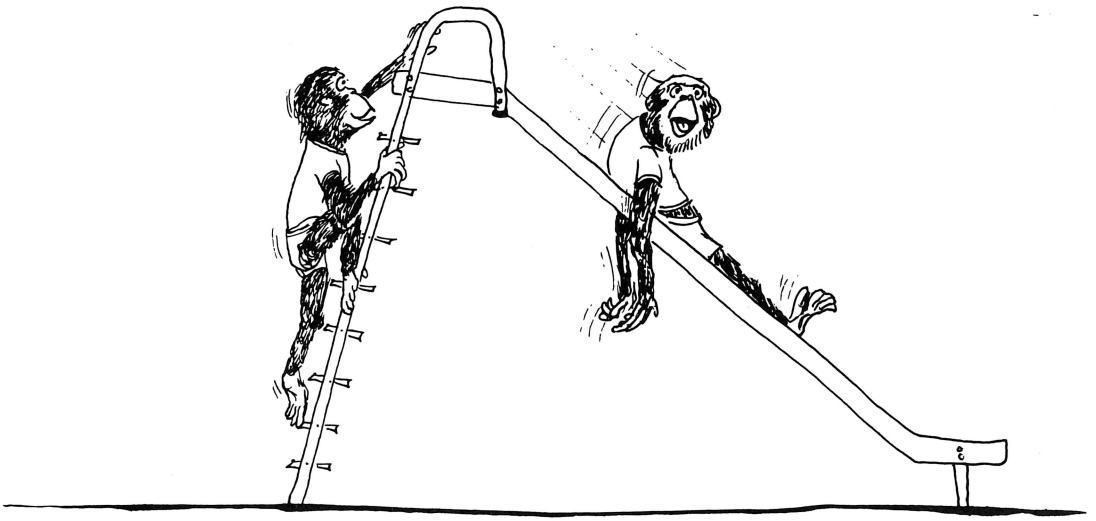
Sample Run

```
                EVERGREEN KEY


CHOOSE THE DESCRIPTION WHICH
BEST FITS YOUR TREE'S NEEDLES.


1.  SHORT AND FLAT WITH WHITE
    UNDERSIDES

2.  LONG, THIN AND SMOOTH

3.  TIGHTLY CLUSTERED, PRICKLY
    AND SCALE-LIKE
```

```
4.  SHORT, THICK AND SHARP

TYPE IN THE NUMBER OF YOUR CHOICE.

?2

THE TYPE OF TREE
YOU ARE KEYING IS A  PINE.

CHOOSE THE DESCRIPTION WHICH
BEST FITS THE PINE NEEDLE.

1.  2 NEEDLES IN A CLUSTER

2.  3 NEEDLES IN A CLUSTER

3.  5 NEEDLES IN A CLUSTER

TYPE IN THE NUMBER OF YOUR CHOICE.

?3
THE TYPE OF PINE
YOU ARE KEYING IS A WHITE PINE.
```

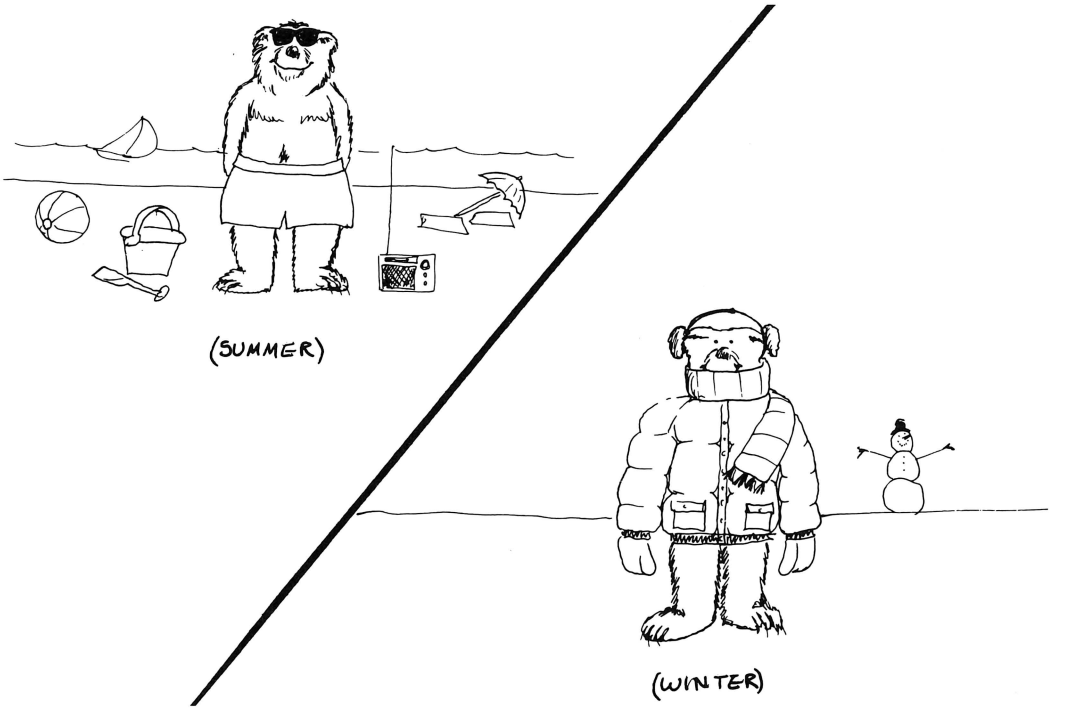
POPULATION SIMULATION

When you run around your home or school with no regard for the rules, you are often told that you're acting like an animal.

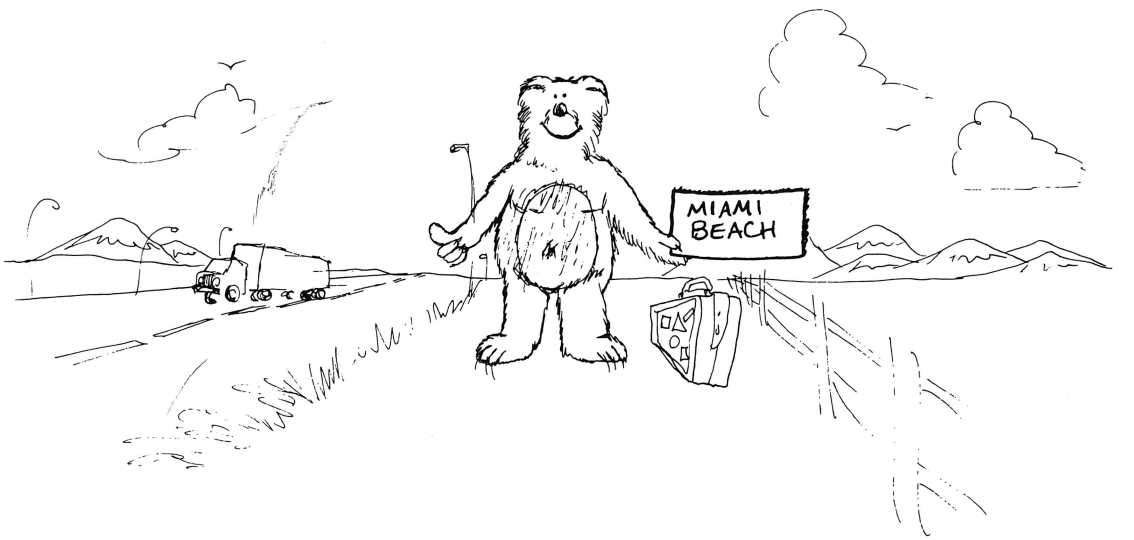


The truth is, animals behave according to rules too. Some of these rules describe how much food is allowed for each individual. Some have to do with living conditions and crowding. Others predict

how many offspring each pair will have. Still others limit the temperature range of that animal, resulting in specific *habitats* (living places) for specific animals.



The enforcer behind these laws is nature itself. If any animal tries to overstep its bounds of temperature, crowding, or feeding,



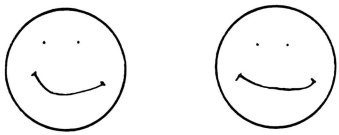
death might occur. If the animal dies before it can produce offspring, the same mistake probably won't be repeated. If this happens to all of the individuals of one type, that type of animal becomes *extinct.*

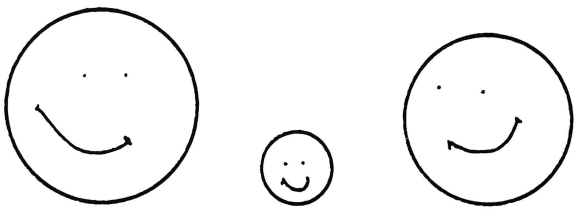
Lately, it seems that more and more animals are becoming extinct. Much of this extinction happens because humans have de-

cided to change the rules by removing habitats, creating overcrowding, and removing food from the environment.

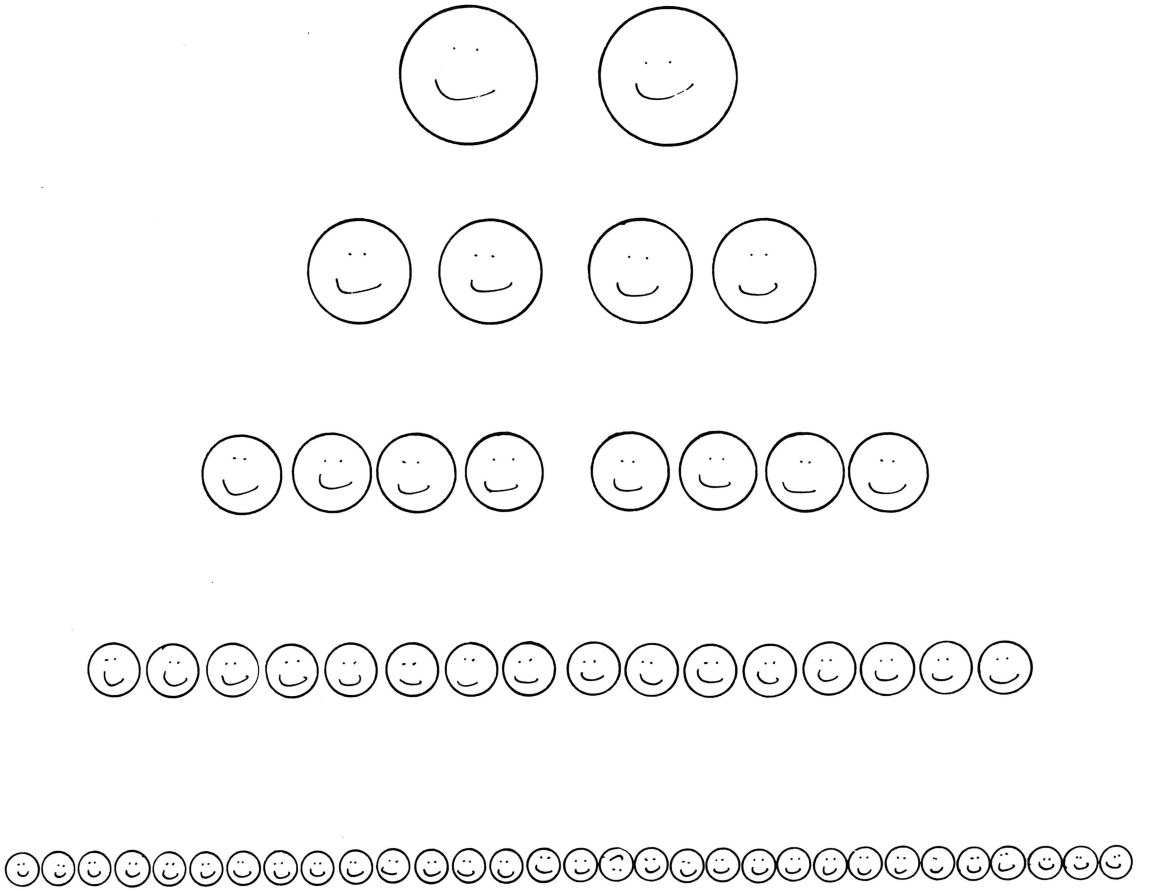
Our computer simulation is designed to show you how a *population* (meaning "more than one individual") will develop if the rules remain the same. If you'd like, there are some ways to change the rules by changing the ways that the program predicts the population.

How does a computer imitate life? The history of a population can be put into mathematical terms. You start with a certain number of individuals. Every time these individuals have offspring, the population is added to. Adding to a population is called *growth.* Because every new member means less space and food for the population,





more deaths will occur. Every time there's a death, the population gets that much smaller. Getting smaller is known as *decay.*



This can be written as an equation:

Population Size = Starting Size + Growth − Decay

Notice that we used addition and subtraction to figure in growth and decay. If the amount of births or deaths (or both) gets very large, you need to use multiplication (for growth) or division (for decay).

Every time there's a change in the population — at least one birth or death — you need to do another "head count." The program does one head count per generation. A generation is defined as the time it takes for that type of animal to reach childbearing age. For each type of animal, you must tell the Apple how many times it will

give birth in its lifetime, and how many offspring it has each time. From that, the Apple displays the results of each generation. Here are values for some animals to get you started:

Species	Number of Offspring	Births per lifetime
Gypsy Moth	100 to 1200	1
Fruit Fly	100	1
Bullfrog	250	1 to 8
White-Footed Mouse	6	3

Your library or encyclopedia can supply similar numbers for other animals.

Program Listing

```
10  HOME
20  PRINT "          POPULATION SIMULATION"
30  PRINT
40  PRINT
50  PRINT " YOU CAN SIMULATE GROWTH RATES"
60  PRINT " FOR ANY SPECIES OF ANIMAL WITH"
70  PRINT " RESEARCHED FACTS:  THE NUMBER"
80  PRINT " OF OFFSPRING PER EFFORT AND"
90  PRINT " NUMBER OF EFFORTS PER LIFETIME."
100  PRINT
110  PRINT " WHAT SPECIES' POPULATION ARE"
120  PRINT " WE SIMULATING?"
130  INPUT S$
140  PRINT
150  PRINT
160  PRINT " HOW MANY ";S$;"S PER LITTER,"
170  PRINT " CLUTCH, BROOD, ETC.?"
180  INPUT L
190  PRINT
200  PRINT
210  PRINT " HOW MANY TIMES (NUMBER OF )"
220  PRINT " LITTERS, ETC.) DO ";S$;"S"
230  PRINT " REPRODUCE IN THEIR LIFETIME?"
240  INPUT T
250  PRINT
260  PRINT
270  PRINT " HOW MANY GENERATIONS SHALL WE"
280  PRINT " RUN THE SIMULATION? (1 TO 20)"
290  INPUT X
300  HOME
310 N = 2
320  FOR G = 1 TO X
330  PRINT " IN GENERATION NUMBER ";G;" THERE"
```

```
340   PRINT "ARE "; INT (N);" ";S$;"S !!!"
350   PRINT
360 N = N * ((L * T) / 2)
370   NEXT G
380   END
```

Explanation

The variable list and program description are given here.

s$	name of animal (plural)
l	number of young in an s$ litter
t	number of times that s$ reproduces in its lifetime
x	number of populations in the simulation
g	counter for generations
n	number of s$ after each generation

Lines 10-100. Prints the introduction and explanation.

Lines 110-150. Gets the name of the species.

Lines 160-200. Using the name which you gave, gets the number of them born every time they give birth.

Lines 210-260. Finds out how many times these animals give birth in a single lifetime.

Lines 270-300. Asks the number of generations that you want to calculate for.

Line 310. Sets the number of animals to two at first.

Line 320. The start of the loop which has g counting from 1 to the number x you entered in line 290.

Lines 330-350. Prints the number of animals in each generation.

Line 360. Calculates the number in the next generation. l × t is divided by 2, assuming that one-half of all of the animals born will die before being able to reproduce. Like the text says, you can change this for other survival rates.

Line 370. If you haven't gone through x generations yet, calculate the number of values in the next one.

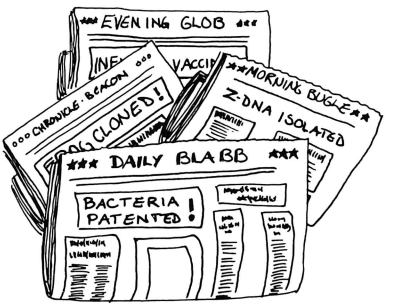
Sample Run

```
                POPULATION SIMULATION


YOU CAN SIMULATE GROWTH RATES
FOR ANY SPECIES OF ANIMAL WITH
RESEARCHED FACTS:  THE NUMBER
OF OFFSPRING PER EFFORT AND
NUMBER OF EFFORTS PER LIFETIME.
```

```
 WHAT SPECIES' POPULATION ARE
 WE SIMULATING?
?GIRAFFE

 HOW MANY GIRAFFES PER LITTER,
 CLUTCH, BROOD, ETC.?
?1

 HOW MANY TIMES (NUMBER OF )
 LITTERS, ETC.) DO GIRAFFES
 REPRODUCE IN THEIR LIFETIME?
?5

 HOW MANY GENERATIONS SHALL WE
 RUN THE SIMULATION? (1 TO 20)
?5
 IN GENERATION NUMBER 1 THERE
ARE 2 GIRAFFES !!!

 IN GENERATION NUMBER 2 THERE
ARE 5 GIRAFFES !!!

 IN GENERATION NUMBER 3 THERE
ARE 12 GIRAFFES !!!

 IN GENERATION NUMBER 4 THERE
ARE 31 GIRAFFES !!!

 IN GENERATION NUMBER 5 THERE
ARE 78 GIRAFFES !!!
```

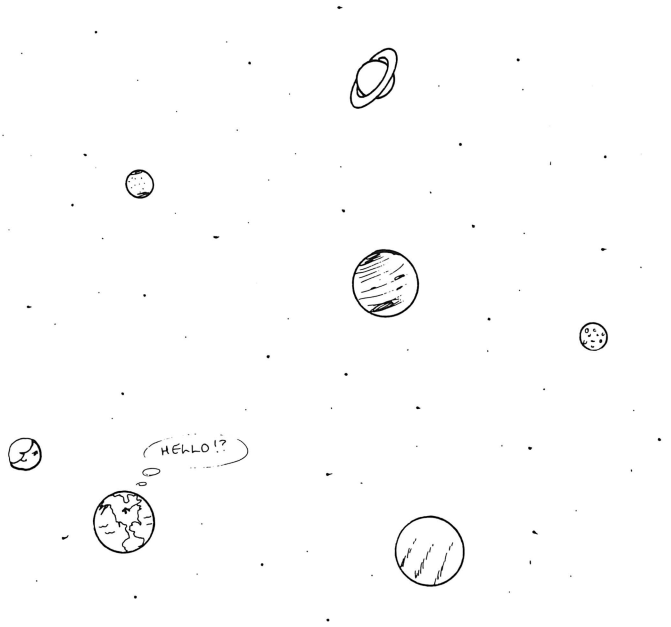
BIOLOGY MATCHING QUIZ

Most people seem to find biology the most exciting and intriguing of today's sciences. It's hard to pick up even the most general of magazines without seeing headlines concerning the origins of life, the

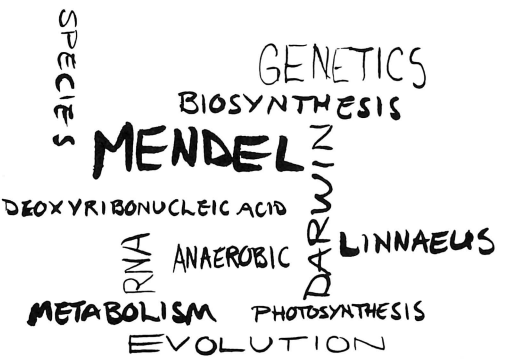


debate over theories of creation, the advances in health and medicine, and even the patenting of new organisms that have been produced in laboratories.

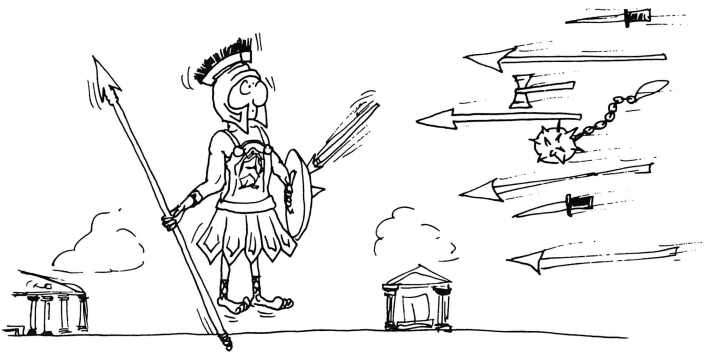
Some of this interest is due to the way that biology combines and coordinates most of the other natural sciences. Some of it is due to the fact that we humans are biological creatures. Some of it is also



due to the fact that the inhabitants of planet earth are the only life forms known to exist in the universe (but we're still looking). Whatever the reasons, some of the words of biology, its terminology, have crept into everyday language. Such names as Darwin, Mendel, and Linnaeus, and terms such as species, biosynthesis, metabolism, and deoxyribonucleic acid (DNA) are becoming less foreign each day. We designed this program to see how many of those terms you can recognize.

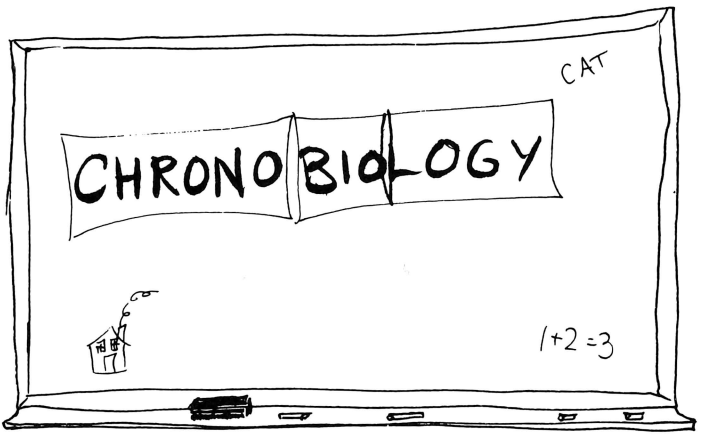


Here's a little preparatory note: The Romans had a unique way of overtaking an army that was larger than theirs. The technique translates to "divide and conquer." They would isolate and overtake small segments of the enemy forces. It was much easier to outnumber ten men ten times than to take on the whole hundred at once.



While we hope you never have to do that in reality, we suggest that you use a similar technique to conquer difficult terms.

For instance, when faced with the new term *chronobiology*, first divide the word up into smaller segments.



You might recognize "chrono" from other words, such as *chronometer*. A chronometer is a device for measuring (metering) time, so you can be pretty sure that "chrono" has the root meaning time. Biology you already know to be the study of life, so that you can now put this all back together to get chronobiology = time / life / study, or, the study of the effects of time on living things.

You might find that this helps you to understand words. Separate them according to their roots.

After running this program a few times, you'll most likely remember the answers, and the challenge will be gone. It's fairly easy, however, to change the words and definitions. They are all contained in DATA statements at the end of the program, in the following fashion:

TERM1,DEFINITION1,TERM2,
DEFINITION2,TERM3,DEFINITION3,ETC. . .

Nobody will feel insulted if you decide not to stick to biology. This quiz works just as well with terms from physics, chemistry, art, literature, comic books, or whatever. It's also a great way for you and your friends to swap trivia quizzes!

Program Listing

```
10  HOME
20  PRINT "           BIOLOGY MATCHING QUIZ"
30  PRINT
40  PRINT
50 A = 1
60 B = 5
70 T = 0
80  FOR I = 1 TO A
90  FOR J = 1 TO B
100  READ A$(J),B$(J)
110  NEXT J
120  FOR K = 1 TO B
130 C =  INT ( RND (1) * B) + 1
140  IF C$(C) <  > "" THEN 130
150 C$(C) = B$(K)
160  NEXT K
170  FOR J = 1 TO B
180  PRINT A$(J); TAB( 10);J;" ";C$(J)
190  NEXT J
200  PRINT
210  PRINT "TYPE IN THE NUMBER OF THE "
220  PRINT "CORRECT MATCH."
230  PRINT
240  FOR J = 1 TO B
250  PRINT A$(J);"--";
260  INPUT X
270  IF X > B THEN 250
280 E$(J) = C$(X)
290  NEXT J
300  FOR J = 1 TO B
310  IF E$(J) <  > B$(J) THEN  GOSUB 400
```

```
320  NEXT J
330  IF T = 0 THEN 360
340  PRINT "YOU MATCHED ";T;" INCORRECTLY."
350  GOTO 380
360  PRINT " CONGRATULATIONS!  YOU MATCHED"
370  PRINT " THEN ALL CORRECTLY."
380  NEXT I
390  END
400  PRINT A$(J);"--",B$(J)
410 T = T + 1
420  RETURN
430  DATA  DARWIN,EVOLUTION=SURVIVAL                    OF THE FITTEST
440  DATA   MENDEL,DISCOVERED THE ROLE                OF GENES IN HEREDITY
450  DATA  FATS,NUTRIENTS USED FOR                  THE STORAGE OF ENERGY
460  DATA   D.N.A.,CHEMICAL WHICH                     CARRIES GENETIC
                    INFORMATION
470  DATA   PROTEINS,NUTRIENT USED AS                   STRUCTURES AND ENZY
MES
```

Explanation

This section contains the variable definitions and an explanation of how the program operates.

b	number of matching terms
t	number of wrong matches made
j	counter of matching terms
a$	name (item in column 1)
b$	definitions
k	counter for random printing order
c	random order for printing definitions
c$	printing assignments for b$'s
x	your answer's number
e$	your answer's definitions

Lines 10-40. Prints the header.

Lines 50-60. Sets number of terms to 5, and the number incorrect to 0.

Line 70. Begins the data-reading loop.

Line 80. Reads data from lines 400-440. The first element is the name and is called a$ (there are j of them), and the second term, the definition, is called b$ (there's j of them).

Line 90. Reads the next set of names and definitions.

Line 100. Begins the loop for picking a random order for printing the definitions on the screen.

Line 110. Picks a random number.

Line 120. Checks to see if there is already a term stored in the c$(c). If so, it picks another random number.

Line 130. Makes the Cth c$ the same as the Kth b$.

Line 140. Does this for each of the 5 terms.

Lines 150-170. Prints the terms and the scrambled definitions on the screen.

Lines 180-210. Header for asking answers.

Line 220. Begins the loop for collecting answers.

Line 230. Prints the name and a dash.

Lines 240-260. Accepts your answer, makes sure that it's 1, 2, 3, 4, or 5, then puts the term for that number into e$.

Line 270. Continues the loop for the next name.

Line 280. Starts the loop to compare answers.

Line 290. Compares e$ (your answer) to b$ (the correct answers). If they do not match, prints the correct match (lines 370-390).

Line 300. Compares the next answer.

Line 310. Checks for no wrong answers.

Line 320. Prints the number which you matched incorrectly.

Line 330. Goes to the end.

Lines 340-350. Message for no wrong answer.

Line 360. The end.

Lines 370-380. Prints the correct answers to your wrong answers. Adds 1 to t.

Line 390. Returns to line 300.

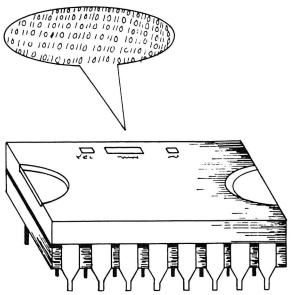
Lines 400-440. The data. On each line, there is a term, a comma, and a definition. The comma tells Applesoft Basic that these are two different sets of words. Note the balloons showing the number of spaces between certain words? Those are important to make sure that the definitions appear correctly on the Apple's screen. If you decide to change this program, like it suggests in the text, try the terms first with no spaces, then add them until the screen looks O.K. If you change the number of terms which you would like to have, change line 50 so that b equals the number of terms you want to have.

Sample Run

```
BIOLOGY MATCHING QUIZ


DARWIN          1 DISCOVERED THE ROLE
                  OF GENES IN HEREDITY
MENDEL          2 CHEMICAL WHICH
```

```
                    CARRIES GENETIC
                    INFORMATION
FATS            3 EVOLUTION=SURVIVAL
                    OF THE FITTEST
D.N.A.            4 NUTRIENTS USED FOR
                    THE STORAGE OF ENERGY
PROTEINS            5 NUTRIENT USED AS
                      STRUCTURES AND ENZYME
S

TYPE IN THE NUMBER OF THE
CORRECT MATCH.

DARWIN--?3
MENDEL--?1
FATS--?4
D.N.A.--?2
PROTEINS--?5
 CONGRATULATIONS!  YOU MATCHED
 THEN ALL CORRECTLY.
```

5



Adventures in Mathematics and Computer Science

This whole book to this point has been an adventure in computing. You've had to learn how to use Applesoft Basic to get this far, and you've gotten used to most of the habits of your Apple.

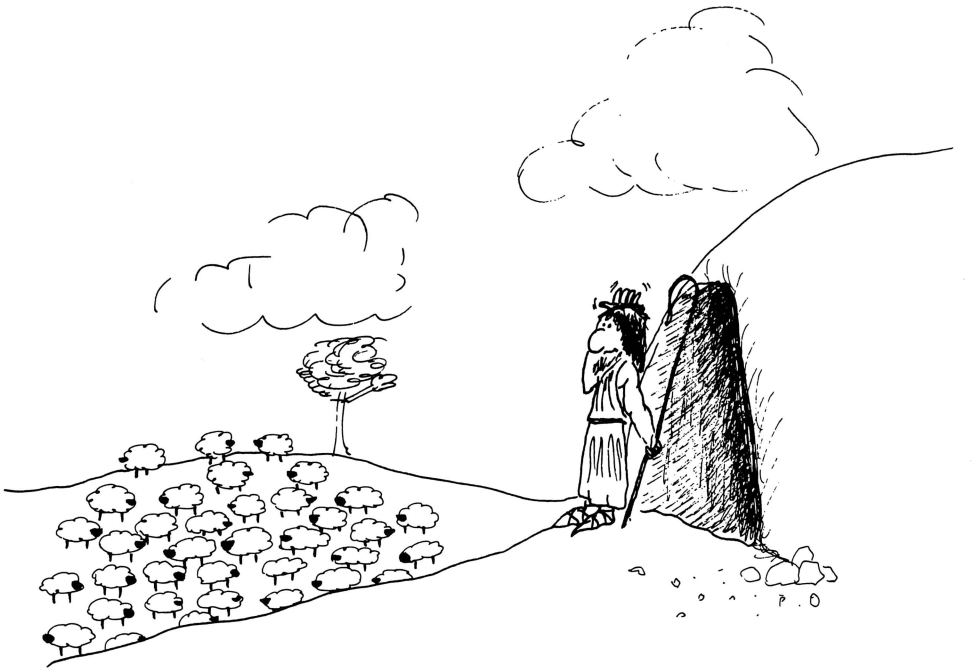
In this set of adventures, you'll go down deeper into the workings of the computer, to discover how it does its figuring, record keeping, etc. Because the computer is really an overgrown adding machine, we'll back things up with some practical math skills — ones that, as scientists, we know are useful. So put away your shovel — all that you'll need to dig deeper is this book, your faithful Apple, and some time to try the adventures that follow.

BASE CONVERTER

In a way, mathematics is another language, like French, Greek, or Chinese. Like any language, you use it to describe and explain the world. You already know about numbers, numerals, and digits from math class. You know how to combine and change them through addition, subtraction, multiplication, and division. But in glancing through your computer manuals, you're more likely to see the terms *bits, bytes,* and *addresses* floating around. We'll talk about those, and how similar you and the computer are when it comes to math.

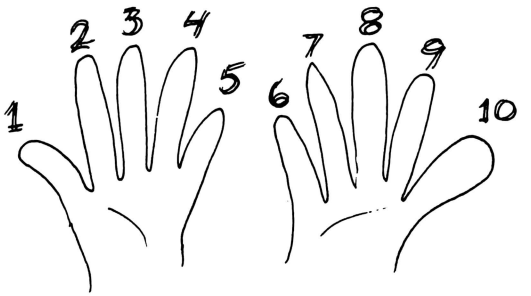
We humans usually count in *base 10.* This means that the basis for our numbering system has 10 digits (zero to nine). Why not four? Or seven? Or 13?

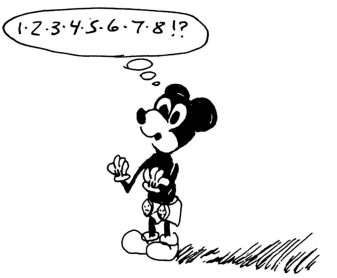
Keep in mind that we didn't always have counting machines. Some poor soul found out that he had to take care of more cattle than



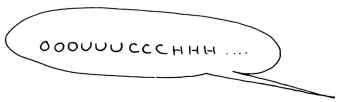
he could keep his eye on. He began to search for some objects that could stand for the number of cattle he had.

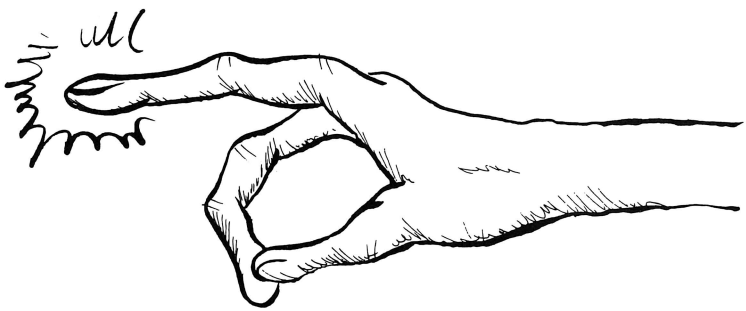
A certain genius, whose name is lost to history, found that ten fingers made a perfectly workable counter. At that point, the system

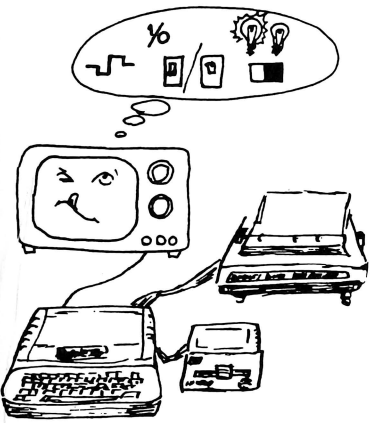




of counting using ten digits was born. If humans had only three fingers, we'd be counting in base three. We'd be using base 20 if we



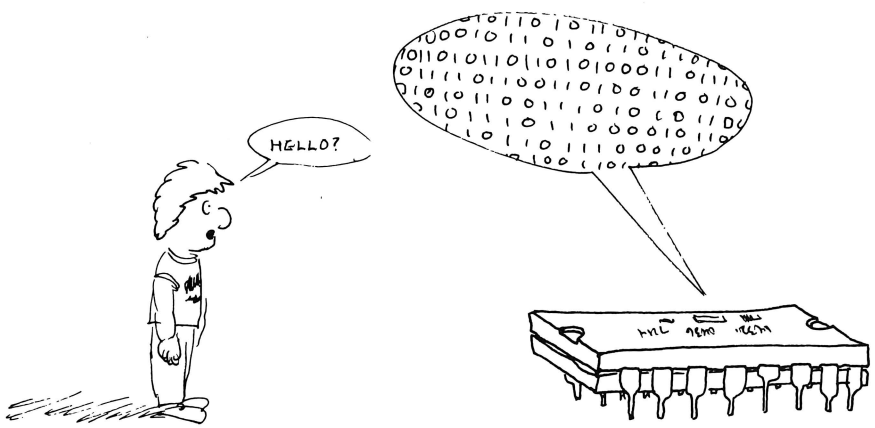




had included our toes. If that practice was ever in effect, it probably ended with the invention of shoes.

At any rate, the base that you use depends on how many digits you have to work with. Computers, being electronic, can only use base two. Why? Because the electronic switches that make them up only have two possibilities: *on* or *off*. In numbers, this means you only have one or zero to deal with (in logic, true or false). Any system that has two states is called *binary*. This is the counting system of all digital computers.

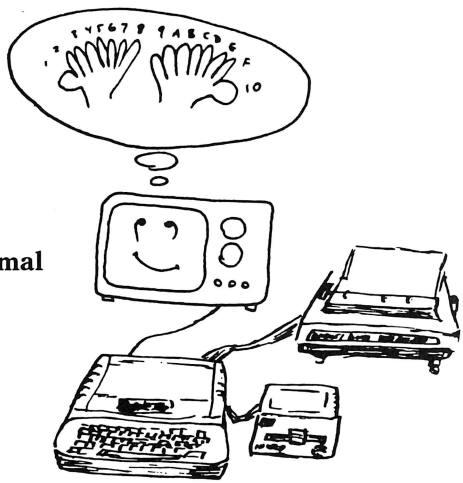
Sooner or later, humans and computers need to communicate.



This means that they must have a common language. Computers are too simple to count in decimal, and humans are too impatient to count in binary. A middle ground is struck through the use of an interpreter. If the interpreter is an *assembler*, the conversation takes place using *hexadecimal* numbers (base 16), and is easier for the computer to understand. If the translator is Applesoft Basic, the conversation takes place in a rough form of English and *decimal* numbers, and is easier for the human. Other translators (Fortran, Logo, Pascal, etc.) are also attempts to make life easy on both man and machine.

What about base 16? How is it possible to have a base higher than the numerals which we invented? Easy. We steal some from the alphabet (after all, a symbol is a symbol). In hex (as hexadecimal is usually called) the digits are:

0 1 2 3 4 5 6 7 8 9 A B C D E F

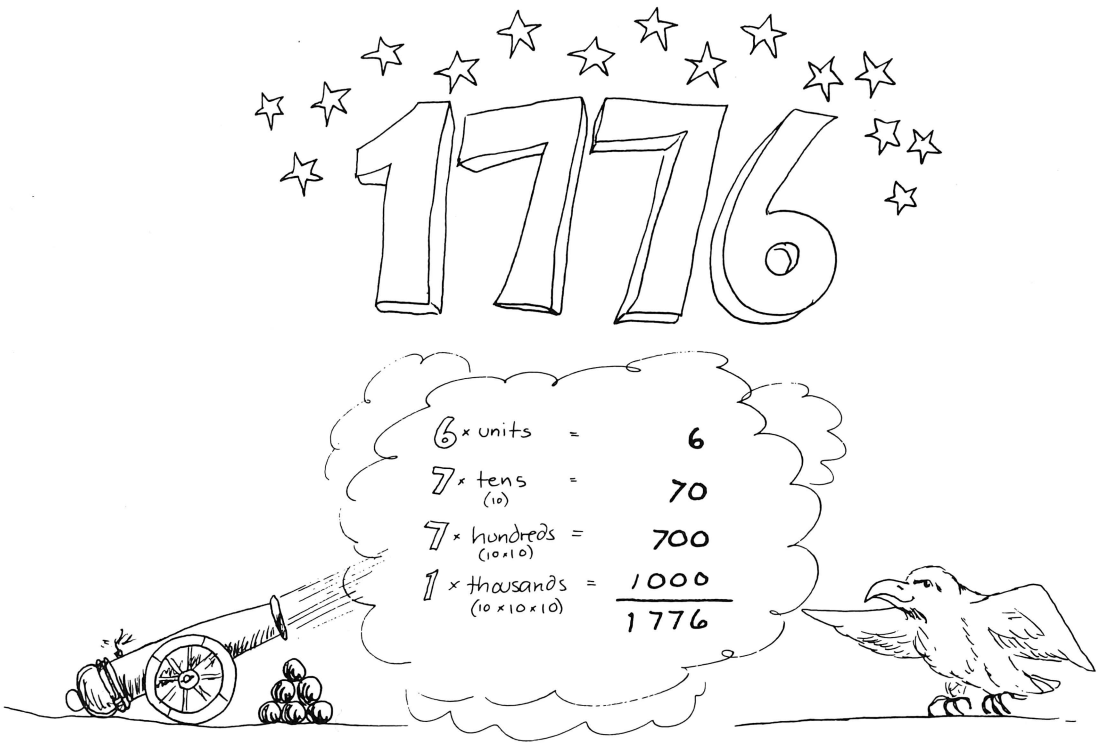


Let's compare decimal and hexadecimal:

Things	Decimal	Hexadecimal
	0	0
.	1	1
..	2	2
...	3	3
....	4	4
.....	5	5
.....	6	6
.....	7	7
.....	8	8
.....	9	9
.....	10	A
.....	11	B
.....	12	C
.....	13	D
.....	14	E
.....	15	F
.....	16	10
.....	17	11

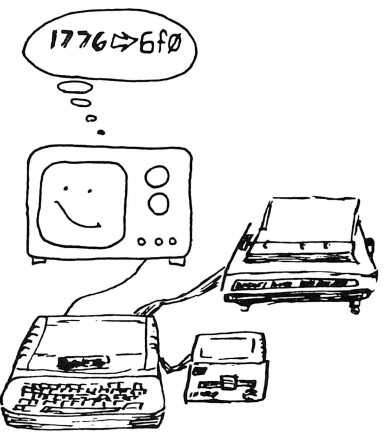
Notice that when you get as many things as you have digits in your base, you need to add digit. And when you get base-times-base things, you'll have to add another digit. Each digit to the left stands for the next *power* of the base. To really see how this works, let's take apart a familiar number, 1776.

You can see how each numeral in the number stands for a different power of ten.



The same is true for numbers in base 16. For instance, the hex number 3E4F is really:

	$F \times 1$	$= 15$
plus	4×16	$= 64$
plus	$E \times 16 \times 16$	$= 3584$
plus	$3 \times 16 \times 16 \times 16$	$= 12288$
		15951



The method is the same, only the digits and place values are different.

Chances are, if you get into advanced graphics or music or other fancy programming on the Apple, life will be much easier if you know something about hex. It's this numbering system that the Apple uses to number the locations of all of the memory space in the machine, and all of the instructions that are needed to speed up Applesoft Basic programs.

The program in this adventure will convert the two bases (decimal and hexadecimal) back and forth, depending on which one you have or need. It will also show you the same number in binary, although you have no way of speaking to your Apple in binary.

If you'd like to test your own conversion skills, there's a quiz at the end of the program for you to try.

Program Listing

```
10  HOME
20  PRINT "              BASE CONVERTER"
30  PRINT
40  PRINT
50  PRINT "   THIS PROGRAM WILL CONVERT A"
60  PRINT "   NUMBER OF ANY BASE FROM 2"
70  PRINT "   THROUGH 16 TO A DECIMAL NUMBER."
80  PRINT
90  PRINT "   WHICH WOULD YOU LIKE TO DO?"
100  PRINT "    1.  SIMPLE CONVERSION"
110  PRINT "    2.  QUIZ"
120  PRINT "    3.  STOP"
130  INPUT Q
140  ON Q GOTO 150,270,640
150  PRINT
160  PRINT "  O.K., WHAT IS THE BASE OF"
170  PRINT "  YOUR NUMBER?"
180  INPUT B
190  IF B > 16 THEN 150
200  PRINT
210  PRINT "  NOW TYPE IN THE NUMBER."
220  INPUT N$
230  GOSUB 390
240  PRINT "    YOUR NUMBER CONVERTED TO A"
250  PRINT "    DECIMAL IS ";X
260  GOTO 80
270  GOSUB 510
280  PRINT "    O.K., THE BASE IS ";B
290  PRINT "    THE NUMBER IS ";N$
300  PRINT "    TYPE IN THE DECIMAL EQUIVALENT."
310  INPUT Y
320  GOSUB 390
330  IF Y = X THEN 370
340  PRINT "    WRONG, THE CORRECT ANSWER IS"
350  PRINT "IS ";X;"."
360  GOTO 80
370  PRINT "GREAT!!!"
380  GOTO 80
390 E = 0
400 X = 0
410  FOR I =  LEN (N$) TO 1 STEP  - 1
```

```
420 A$ =  MID$ (N$,I,1)
430  IF  ASC (A$) > 57 THEN 460
440 A =  VAL (A$)
450  GOTO 470
460 A =  ASC (A$) - 55
470 X = X + A * B ^ E
480 E = E + 1
490  NEXT I
500  RETURN
510 N$ = ""
520 B =  INT ( RND (1) * 2) + 2
530 B = 2 ^ B
540  IF B = 4 THEN B = 2
550 R =  INT ( RND (1) * 4) + 1
560  FOR I = 1 TO R
570 C =  INT ( RND (1) * B)
580  IF C > 9 THEN 610
590 N$ = N$ +  STR$ (C)
600  GOTO 620
610 N$ = N$ +  STR$ ( CHR$ (C + 55))
620  NEXT I
630  RETURN
640  END
```

Explanation

The variable list and program explanation is given here.

q	choice of convert/quiz
b	base of the number to be converted.
n$	the number to be converted
x	decimal equivalent of the number in n$.
y	your quiz guess;
e	exponent for base b.
a	ASCII code for the digits in n$.
a$	individual digits in n$.
r	length of the number in n$.
c	random digit in n$

Lines 10-120. Prints the introduction and menu (convert, quiz, stop).

Lines 130-140. Asks for your menu choice, and sends control to the proper subroutine (convert=150, quiz=270, end=640).

Lines 150-190. Asks for the base of the number to be converted. If greater than 16, asks again.

Lines 200-220. Asks for the number itself (Note: if you are using base 16, hexadecimal, you must put the non-numerics A, B, C, D, E, F, in CAPITAL LETTERS or the program will not work!).

Line 230. Calls the subroutine lines 390-500 (see below).

Lines 240-260. Displays your number and returns to the menu.

Line 270. Calls the subroutine (lines 510-630) which chooses a random base and number for the quiz.

Lines 280-310. Displays the base and number, and asks for its decimal equivalent.

Line 320. Calls the subroutine which converts your decimal number to the chosen base.

Line 330. Checks to see if your number matches the one which it chose, if it does, goes to the correct answer message, line 370.

Lines 340-360. Corrects you if your guess is wrong, and returns to the menu.

Lines 370-380. Prints the correct answer message and returns to the menu.

Lines 390-400. Sets the exponent (digit place minus one) and digit values to zero.

Line 410. Starts the loop which takes n$ and converts it to base b.

Line 420. Takes the last (and in the next loop, the next to the last; and so on . . .) digit in n$ and calls it a$.

Line 430. If the digit is a letter (its ASCII code is greater than 57), it goes to the line which converts to a value (line 470).

Lines 440-450. Turns the digit in a$ into a number. Goes to the converter (line 470).

Line 460. If a$ was a letter, subtracts 55 from its ASCII code to turn it into a letter.

Line 470. Builds the decimal equivalent by changing each digit to the value of that digit multiplied by the base raised to the proper exponent.

Line 480. Raises the number of the exponent (digit place minus one).

Line 490. Sends the program to line 410, lowering the digit count by one.

Line 500. Returns to line 230 or 320, depending on which this subroutine was called from.

Line 510. Clears anything that was in n$.

Lines 520-540. Chooses a random base.

Line 550. Chooses the random length of the number.

Line 560. Starts a loop which picks the random digits for the number.

Line 570. Picks a random digit. If greater than 9 (bases 11-16), goes to a conversion routine (line 610) like that in line 460.

Lines 590-600. Adds the next digit to n$, and goes to 620 to continue the loop.

Line 610. If the digit chosen was a non-numeric

(A, B, C, D, E, F), adds 55 to its ASCII code to turn it into character.

Line 620. Continues the loop.

Line 630. Returns to Line 510.

Line 640. The end.

Sample Run

```
                BASE CONVERTER


   THIS PROGRAM WILL CONVERT A
   NUMBER OF ANY BASE FROM 2
   THROUGH 16 TO A DECIMAL NUMBER.

   WHICH WOULD YOU LIKE TO DO?
   1.  SIMPLE CONVERSION
   2.  QUIZ
   3.  STOP
?1

  O.K., WHAT IS THE BASE OF
  YOUR NUMBER?
?2

  NOW TYPE IN THE NUMBER.
?110
   YOUR NUMBER CONVERTED TO A
   DECIMAL IS 6

   WHICH WOULD YOU LIKE TO DO?
   1.  SIMPLE CONVERSION
   2.  QUIZ
   3.  STOP
?2
   O.K., THE BASE IS 8
   THE NUMBER IS 0
   TYPE IN THE DECIMAL EQUIVALENT.
?0
GREAT!!!

   WHICH WOULD YOU LIKE TO DO?
   1.  SIMPLE CONVERSION
   2.  QUIZ
   3.  STOP
?2
   O.K., THE BASE IS 8
   THE NUMBER IS 474
   TYPE IN THE DECIMAL EQUIVALENT.
?61
   WRONG, THE CORRECT ANSWER IS
IS 316.
```

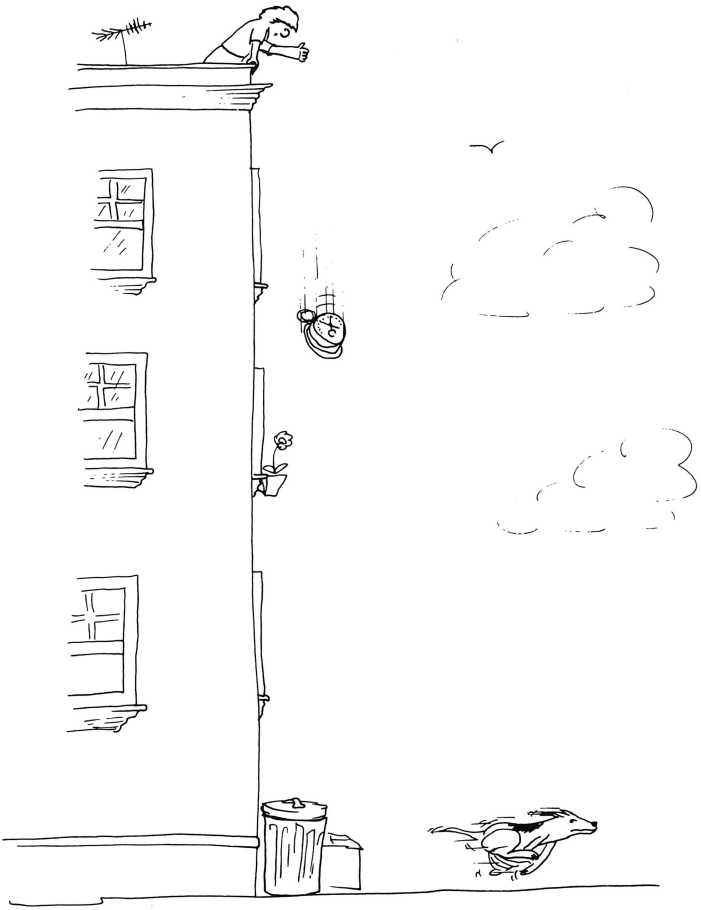
```
   WHICH WOULD YOU LIKE TO DO?
   1.  SIMPLE CONVERSION
   2.  QUIZ
   3.  STOP
?3
```

HEIGHT FINDER

There's a famous story about a student who was taking a test in physics. One of the test questions read something like this:

"You are given a barometer and asked to use it to find the height of a tall building. How would you do it?"

The student quickly wrote that he would go to the top of the building and drop the barometer. By measuring the time it took for

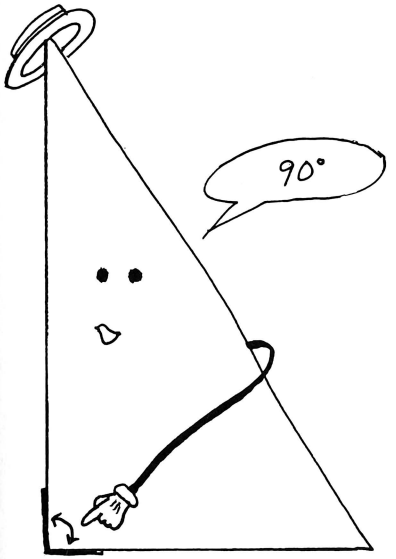


the barometer to crash to the sidewalk, he could calculate the distance to the ground.

His test was marked "wrong" and he was told to try again. His next answer was to tie a string to the barometer, lower it from the roof until it touched the ground, and measure the length of the string.

Again his teacher marked the answer "wrong," and sent him back to start again.

On his third try he suggested taking the barometer (they are fairly expensive) and offering it as a bribe if the building's custodian would tell him how tall it was. His teacher didn't like that answer either, and failed the poor student.

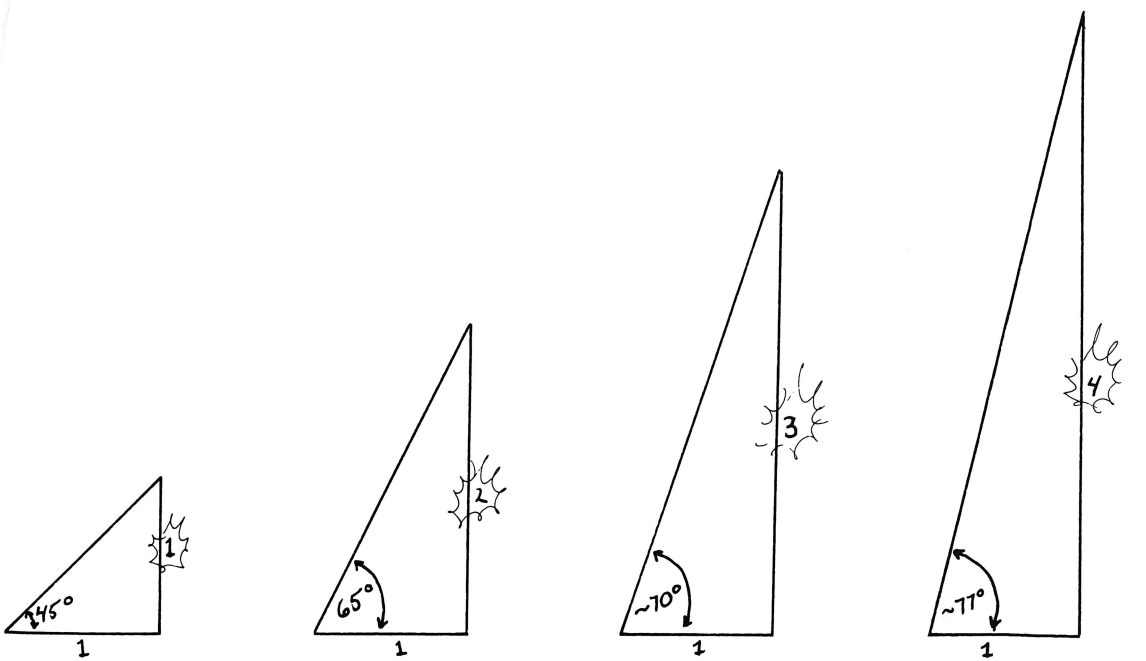


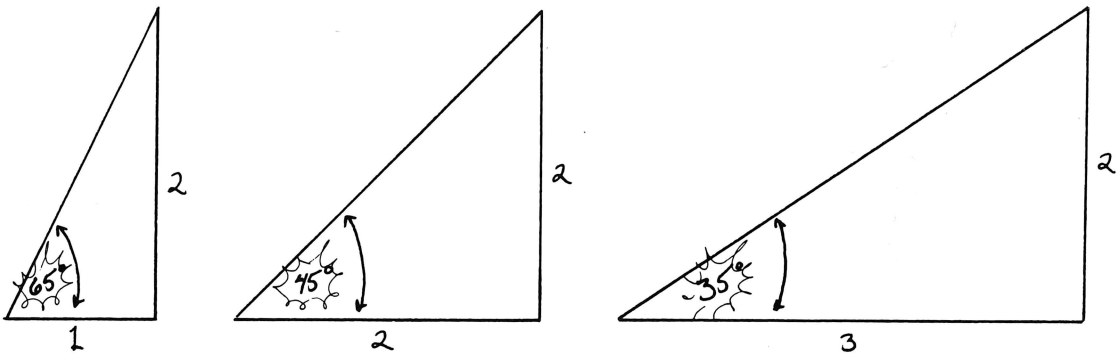
This little fable has two purposes: one, to show you that there is more than one way to solve any problem, and two, to show you how *not* to use the Apple to find heights.

All of our methods are designed to keep your computer's feet safely on the ground. Our method of finding heights will use the Apple as an expert calculator of numbers. It will use you as an expert observer of objects and measurer of angles.

The measurement of angles is the key to measuring heights. Angles are the stuff that geometry and trigonometry are made of. One of the special cases that trigonometry does very well with is *right triangles.* A right triangle is any one which has a right (90 degree) angle in it. We are assuming that any object you want to find the height of is at a right angle to the ground (that means that it's standing up straight). So much for the Leaning Tower of Pisa.

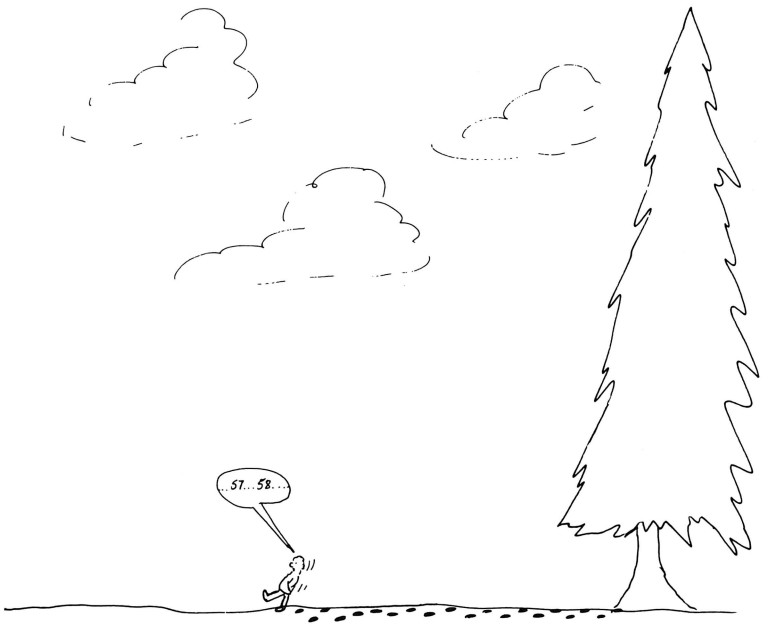
One thing that a trigonometrician (a person who specializes in trigonometry) can tell you is that there is a constant relationship between the side of the triangle that stands up and the angle opposite it. As one gets bigger, so does the other. As one gets smaller, so does the other. "Aha!," you say, "there's a *constant* relationship be-





tween the two!". You're right. What's more, if you make the angle opposite that stand-up side larger, and leave the *base* of the angle the same, the stand-up side gets larger. On the other hand, if the angle gets smaller and the stand-up side stays the same, the base gets larger.

Remember that we said that the stand-up side is the object to be measured. Therefore, we can call the ground our base side. The base is easier to measure. Suppose you want to measure the height of the tallest tree you know of. The first step is to get it in your view. Stand

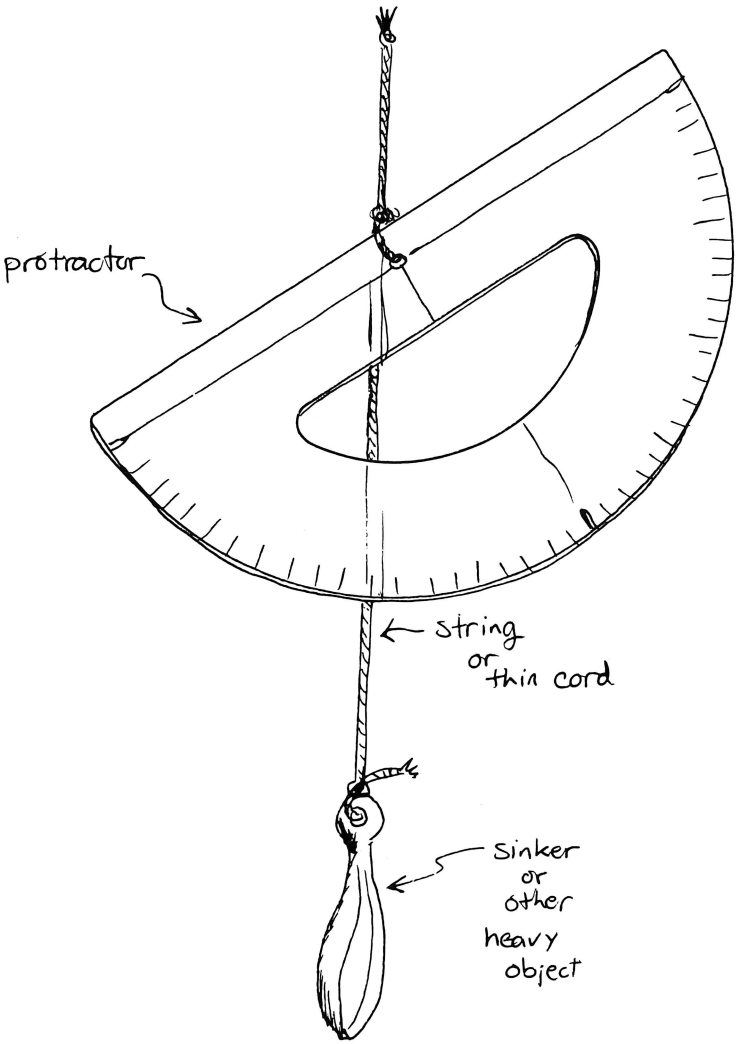


far enough away from it so that you can see its top without tipping your head back too far. Mark the spot where you're standing (your *viewpoint*). Now measure the distance from that spot to the tree (use the same units as you want the tree's height to be in; feet, yards, meters, etc.). This is the number that you will call the base. The

Apple will ask you for this number when you use the Height Finder program.

Next, you need to measure the *elevation angle* (the angle opposite the stand-up side) made when you look at the tree's top. Here's where you need some equipment.

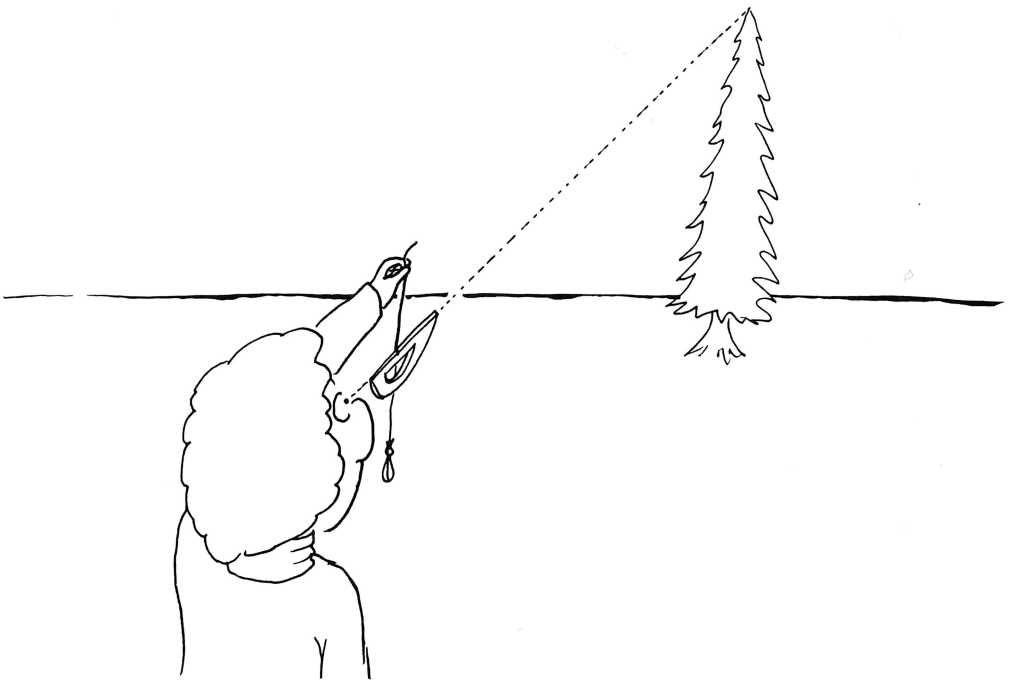
You're going to make a *clinometer.* What you will need is simple: a plastic protractor (just like the one you use in school), a foot of string, and a weight (something like a large fishing sinker, a bolt, or a



set of keys). Tie the string through the hole in the protractor's edge and to the weight.

Now return to the spot that you marked as your viewpoint. Hold the clinometer and line up its flat edge with the top of your tree (see the drawing on page 120). When the weight stops swinging, carefully

trap the string against the protractor. Read the angle on the protractor where the string crosses it. This is the measure of the angle, the other number that the Apple needs. By using a set of constants called *tangents*, the Apple calculates the height of the tree (or building, statue, or antenna) whose base and angle you measured.



Keep in mind that the heights you get are only as accurate as the base and angle that you measure, so take your time. You might want to hold some contests with friends. Let each person measure some object, and then contact authorities and get the actual number.

And by the way, the answer that the physics teacher wanted was: Use the barometer to measure the air pressure at the top of the building and at the bottom of the building. There's an equation to turn the difference between the two into feet (of air).

Program Listing

```
10  HOME
20  PRINT "              HEIGHT FINDER"
30  PRINT
40  PRINT
50  PRINT "   WHICH METHOD ARE YOU USING?"
60  PRINT
70  PRINT "    1.  SHADOW STICK METHOD"
80  PRINT "    2.  CLINOMETER METHOD"
90  PRINT
```

```
100  PRINT
110  PRINT "    ENTER THE NUMBER OF YOUR CHOICE"
120  INPUT M
130  IF M > 2 THEN 50
140  ON M GOTO 150,320
150  HOME
160  PRINT "              SHADOW STICK METHOD"
170  PRINT
180  PRINT
190  PRINT "    HOLD THE METER STICK"
200  PRINT "    VERTICALLY AND MEASURE THE"
210  PRINT "    LENGTH OF THE SHADOW IT CASTS."
220  PRINT
230  PRINT "    ENTER THE LENGTH IN METERS."
240  INPUT L1
250  PRINT
260  PRINT "    ENTER THE LENGTH OF THE"
270  PRINT "    OBJECT'S SHADOW (IN METERS)."
280  INPUT L2
290 H = 12 / L1
300 H =  INT (H * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
310  GOTO 460
320  HOME
330  PRINT "             CLINOMETER METHOD"
340  PRINT
350  PRINT
360  PRINT "    ENTER THE ANGLE UPWARDS FROM"
370  PRINT "    HORIZONTAL AS MEASURED BY"
380  PRINT "    YOUR CLINOMETER."
390  INPUT A
400  PRINT
410  PRINT "    ENTER THE DISTANCE FROM YOU"
420  PRINT "    TO THE OBJECT (IN METERS)."
430  INPUT D
440 H = D *  TAN (A * 3.14 / 180)
450 H =  INT (H * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
460  PRINT
470  PRINT "    THE OBJECT IS ABOUT ";H
480  PRINT "    METERS HIGH."
490  END
```

Explanation

The variable list is given here, and the line-by-line description follows.

- m choice of methods
- l1 length of meter's shadow
- l2 length of shadow of object to be measured
- h ratio of shadow's lengths
- a clinometer angle
- d distance between you and the object to be measured

Lines 10-40. Prints the introduction.

Lines 50-120. Asks which method will be used.

Lines 130-140. Makes sure that you have made a valid choice, then sends you to the right routine; if m=1, it sends you to line 150, if m=2, it sends you to line 320.

Lines 150-220. Instructions for the shadow-stick method.

Lines 230-250. Asks for the meter stick's shadow length (the reference length).

Lines 260-280. Asks for the shadow length of the object being measured.

Lines 290-310. Divides 12 by 11 to get the ratio between the shadows. Because the reference was 1 meter, and the shadow angle is the same, this equals the object's height in meters. Line 300 rounds this to 3 decimal places, while line 310 sends the program to the display routine.

Lines 320-390. Asks for the angle measured using the clinometer.

Lines 400-430. Asks for the distance between you and the bottom of the object you're measuring.

Lines 440-450. Calculates the height based on the distance, the tangent of the angle (the ratio between a triangle's base and its longest side . . .); a*3.14/180 is needed because your clinometer measures angles in degrees, while the computer wants angles measured in radians. There are 3.14/180 radians in each degree (or 57.28 degrees in each radian). Line 450 rounds this to 3 decimal places.

Lines 460-490. Displays the resulting heights in meters.

Sample Run

```
                HEIGHT FINDER


   WHICH METHOD ARE YOU USING?

   1.  SHADOW STICK METHOD
   2.  CLINOMETER METHOD


   ENTER THE NUMBER OF YOUR CHOICE
?1
              SHADOW STICK METHOD


   HOLD THE METER STICK
   VERTICALLY AND MEASURE THE
   LENGTH OF THE SHADOW IT CASTS.
```

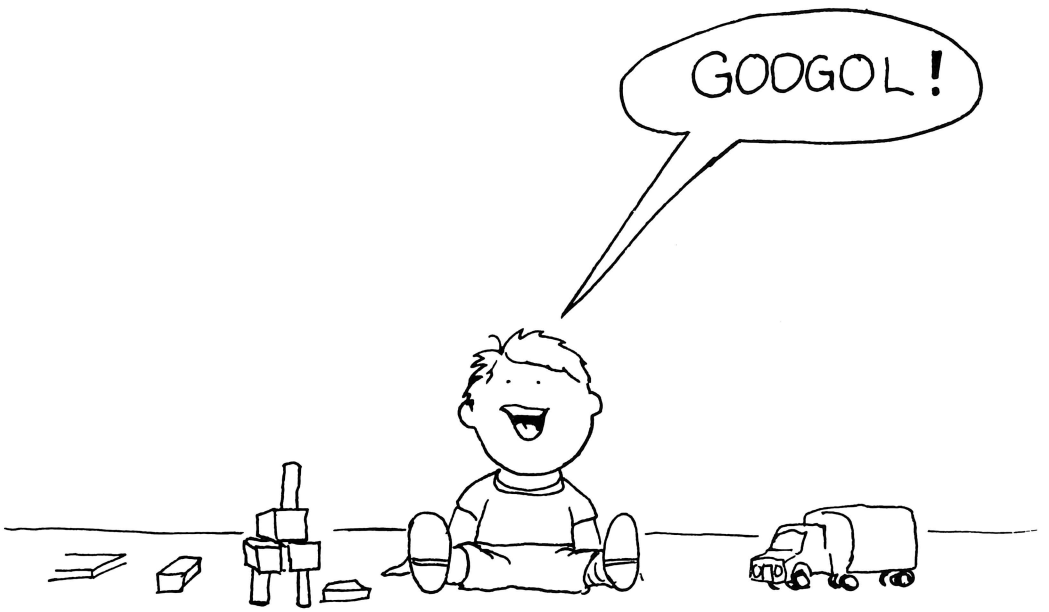
```
   ENTER THE LENGTH IN METERS.
?1.5

   ENTER THE LENGTH OF THE
   OBJECT'S SHADOW (IN METERS).
?12.7

   THE OBJECT IS ABOUT 8
   METERS HIGH.
```

SCIENTIFIC NOTATION

A mathematician named Edward Kasner thinks that he knows a number so large, that nobody could ever need to use it. The number looks like this:

10,000,000,000,000,000,000,000,000,000,
000,000,000,000,000,000,000,000,000,000,000,
000,000,000,000,000,000,000,000,000,000,000,000

He knew that it was larger than a million or a billion or a trillion, and that nobody had a word for a number that large. He needed to call it something, so he asked his seven-year-old nephew to give it a name. He got one.



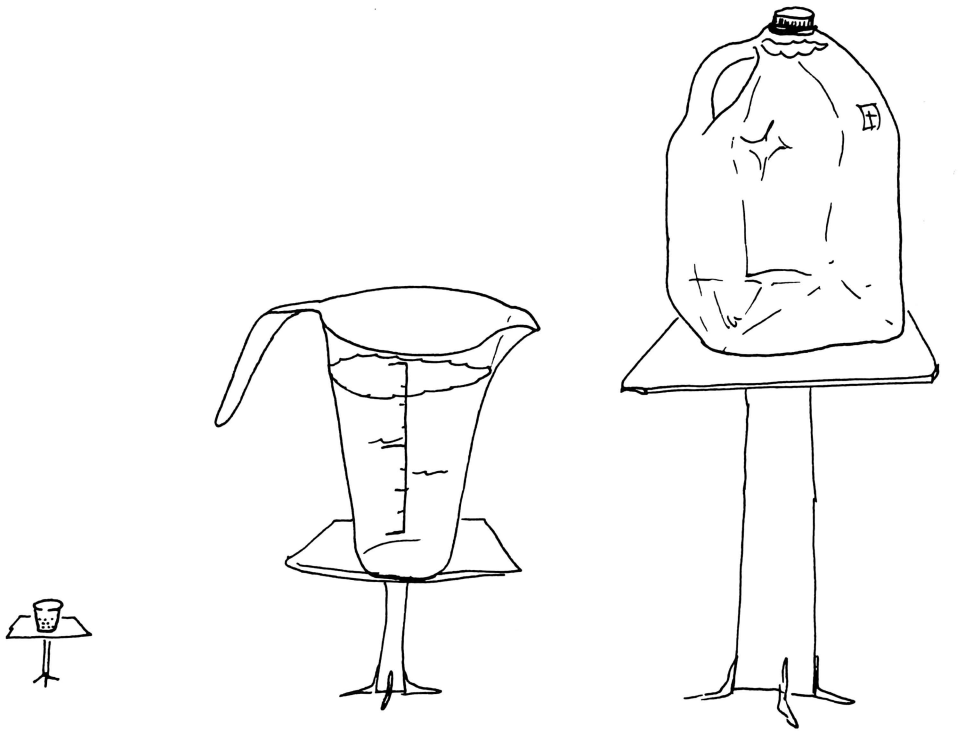
Now, *googol* isn't exactly a technical term, but surprisingly enough, the name has caught on. A physicist or astronomer can tell you that there aren't a googol of objects in the known universe. Some

mathematicians say that they have a use for the googol, but it doesn't involve counting objects.

Counting objects, though, is what most of us use numbers for. We also, as you see in our other adventures, use numbers to stand for locations, conditions, sizes, or sometimes even words (that's how the Apple is able to deal with language). With most things, the bigger they get, the more complicated they are. This is true of numbers.

Suppose that you were in charge of all of the water in a thimble. It's your job to keep track of this water and account for it. Drops seem like a reasonable unit to use to keep track of your thimble's water. You count the drops of water in your thimble, and find out that you have 100 drops.

Your reputation as a water guard grows far and wide. Soon, you're put in charge of a pint (1,920 drops), and then you find



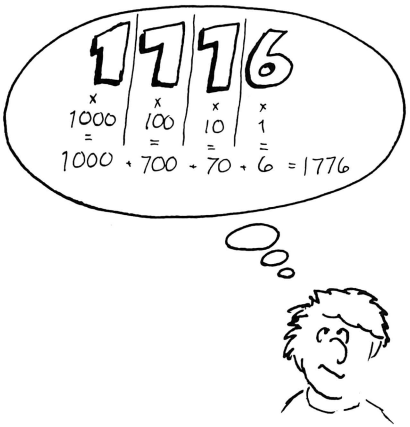
yourself promoted to gallon-guard (a whopping 15,360 drops!). One day, you're put in charge of a lake! Problems develop. It's taking you a long time to count drops, and besides, so much water moves in and out of the lake due to evaporation and rain, that you'll soon spend all of your time recounting.

Luckily, you find refuge in *estimation.* Being exact is not really necessary because you're dealing with such large numbers; an estimate should work well enough. You start at the geography department. They tell you that the lake has an area of 189,362 square feet,

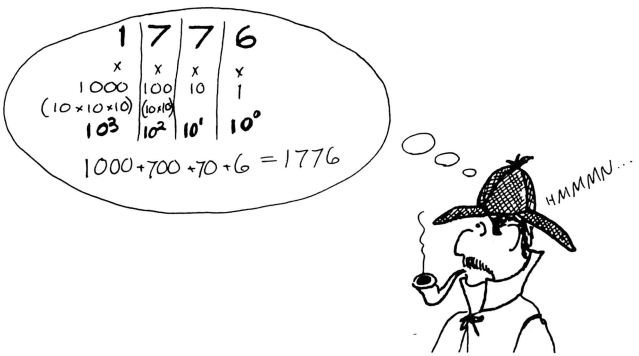
and an average depth of 12 feet, giving a volume of 2,272,344 cubic feet. Because there are 7.48 gallons per cubic foot, your lake contains 16,998,314 gallons of water. From your old guarding job, you know that there's 15,360 drops per gallon. That multiplies out to 261,094,103,040 drops!

Just pronouncing that number is quite a mouthful. Most people would be quite happy if you simply told them that there were 261 billion drops in the lake. The billions are the most *significant* figures in this number, because most of the others (millions, thousands, hundreds, tens, and units) change. There is a way to say "billions" in the language of numbers. Let's see how.

We humans count in base ten (for more details, see the Base Conversion Adventure). Each of the places in our numbers stand for a



power of ten. A *power* equals how many times you multiply a number by itself to get a certain value. The easiest example of this is the hundreds column. To get a hundred, you multiply 2 tens ($10 \times 10 = 100$), which equals 10 to the second power. To get a thousand, you multiply 3 tens ($10 \times 10 \times 10 = 1000$), which is 10 to the third power. Ten thousand is 10 to the fourth power, a hundred thousand is 10 to the fifth power, and a million is 10 to the sixth power.

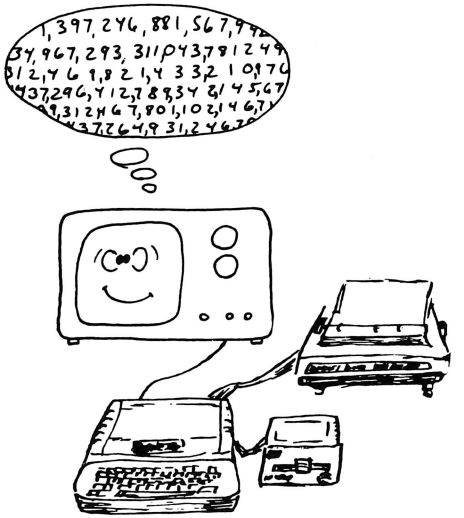


Did you pick up a pattern? The number of zeroes that a place has after the 1 is equal to its *power.* For the tens place, this equals one (there's one zero in the number 10). How about the units? Because there are no zeroes in 1, it's equal to 10 to the zeroth power.

Let's get back to our lake. We said that it had (roughly) 261 billion drops. That's 261 times one billion. If we count the zeroes in one billion, we get nine. Now we can say that the number of drops is 261 times ten to the ninth power. To put this in the language of numbers, we have to make a big jump: we will use a *superscript* to show that we want to raise the number 10 to a power. In the number 10^3, the 10 is normal, and the 3 is the power (and the superscript). That's another way of writing 1000. For a billion, it looks like this: 10^9.

Putting all of this together for our lake, we can say that we have 261 billion, or 261×10^9 drops.

This way of looking at large numbers is quite useful in science (where you often have to deal with large numbers of things), and has earned the name *scientific notation.* It's also a big help to brains that



have trouble holding onto very long numbers. The Apple is one of those brains. In fact, if you try to get the Apple to work with numbers that have nine or more digits in them, it will automatically put them in scientific notation for you. These numbers won't have superscripts on them, due to the limits of a television screen, so this is how you recognize them: the Apple would write your lake-drops like this: 2.61094103 E+11. Here, the E+ stands for "multiply by 10 to the 11th power." An E− would stand for "divide by 10 to the 11th power." Moving over by those 11 places tells you that the Apple figures that there's 261,093,103,000 drops in your lake. Check your

figure: even when using this shorthand method, the Apple is only off by 40.

While scientific notation isn't very helpful when simply counting your fingers or toes, it can be a wonderful tool when the going gets rough and the numbers get large.

By keying in the accompanying program, the Apple will help you to convert numbers to and from scientific notation, give you a chance to practice, and, if you'd like, quiz you on scientific notation.

So how about our large friend, the googol? Because there's 100 zeroes, it must be 10^{100}. We know that you can handle this number. See if the Apple can. If not, how large a number can it compute with?

Program Listing

```
10  HOME
20  PRINT "          SCIENTIFIC NOTATION"
30  PRINT
40  PRINT
50  PRINT "    THIS PROGRAM WILL HELP YOU"
60  PRINT "    TO LEARN SCIENTIFIC NOTATION."
70  PRINT
80  PRINT "    SINCE THE COMPUTER CANNOT"
90  PRINT "    PRINT SMALL NUMBERS, THE"
100  PRINT "     SYMBOL ^ WILL MEAN 'RAISED TO"
110  PRINT "     THE...', FOR EXAMPLE:  "
120  PRINT "     3.812X10^3 MEANS 3.812 RAISED"
130  PRINT "     TO THE THIRD POWER."
140  PRINT
150  PRINT "     YOU WILL BE GIVEN A NUMBER."
160  PRINT "     YOUR JOB WILL BE TO TYPE IN"
170  PRINT "     THE SAME NUMBER IN SCIENTIFIC"
180  PRINT "     NOTATION.  USE NO SPACES AND"
```

```
190  PRINT "    USE X FOR MULTIPLICATION."
200  PRINT
210  PRINT
220  PRINT "    HOW MANY WOULD YOU LIKE?"
230  INPUT M
240 C = 0
250  FOR I = 1 TO M
260  PRINT
270  GOSUB 430
290  PRINT N$
300  PRINT
310  INPUT B$
320 A$ =  LEFT$ (N$,1) + "." +  MID$ (N$,2, LEN (N$)) + "X10^" +
    STR$ ( LEN (N$ ) - 1)
330  IF B$ = A$ THEN 360
340  PRINT "    SORRY, THAT IS NOT CORRECT."
350  GOTO 380
360  PRINT "    GREAT!!!"
370 C = C + 1
380  NEXT I
390  PRINT
400  PRINT "    OUT OF ";M;" PROBLEMS,  YOU"
410  PRINT "  GOT ";C;" CORRECT."
420  END
430 N$ = ""
440 L =  INT ( RND (1) * 7) + 3
450  FOR J = 1 TO L
460 N =  INT ( RND (1) * 9)
470  IF J = 1 THEN  IF N = 0 THEN N = 1
480 N$ = N$ +  STR$ (N)
490  NEXT J
500  RETURN
```

Explanation

The variable list and program description are given here.

m	number of trials
c	number correct
i	counter of trials
n$	number in normal format
b$	your guess for the scientific notation for n$
a$	the scientific notation version of n$
l	length of n$
n	digits to use in n$

Lines 10-210. Prints the introduction and instructions.
Lines 220-230. Asks for the number of trials you'd like.
Line 240. Sets the number correct to 0.
Line 250. Begins the loop that counts trials.

Lines 260-290. Picks and prints a random number between three and ten digits long.

Lines 300-310. Asks for your guess for the scientific notation for n$.

Lines 320-330. Converts n$ to its scientific notation, and compares it to your guess; if they match, prints the congratulatory message in line 360. If not, goes on to line 340.

Lines 340-350. Prints message for wrong answers and goes back to accept another guess.

Lines 360-380. Prints message for correct answer, adds one to c, and goes to the next trial.

Lines 390-420. If all of the trials are done, prints the number of trials and the number correct.

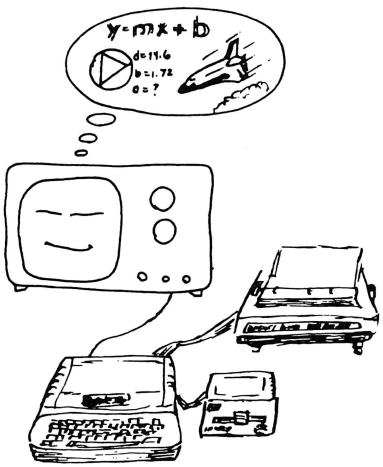
Lines 430-500. Subroutine to build n$ from a random number (1) of digits (n). In line 470, makes sure that the first digit is not 0.

Sample Run

```
          SCIENTIFIC NOTATION

 THIS PROGRAM WILL HELP YOU
 TO LEARN SCIENTIFIC NOTATION.

 SINCE THE COMPUTER CANNOT
 PRINT SMALL NUMBERS, THE
 SYMBOL ^ WILL MEAN 'RAISED TO
 THE...', FOR EXAMPLE:
 3.812X10^3 MEANS 3.812 RAISED
 TO THE THIRD POWER.

 YOU WILL BE GIVEN A NUMBER.
 YOUR JOB WILL BE TO TYPE IN
 THE SAME NUMBER IN SCIENTIFIC
 NOTATION.  USE NO SPACES AND
 USE X FOR MULTIPLICATION.

   HOW MANY WOULD YOU LIKE?
?2

107458477

?1.07458477X10^8
   GREAT!!!

777

?7.77X10^2
   GREAT!!!

   OUT OF 2 PROBLEMS,  YOU
  GOT 2 CORRECT.
```

ALPHABETIC ORDER

Computers are wonderful for doing all of the things that would either take a human brain too long to do or would be too boring for a human mind. Solving equations, doing many math problems, arranging information, and landing a machine that can't really fly in the first place



(the space shuttle) are all best left to computers. We're going to focus on arranging information.

Suppose that you've decided to use the Apple to keep a list of all of your friends' addresses, or the list of references for your term paper, or the words that you've had to learn in biology class. Finding a single entry in this list when you need it could be maddening if the list is a jumble, with no rhyme or reason to its order. What your list needs is some *hierarchy*, something that will never change, even if the list gets bigger or smaller.

There is something in our language that is stable enough to help you out. While words, their spelling, and even their pronunciation all change over time, the list of letters that make up these words hasn't changed for thousands of years. That list is called the alphabet. The name comes from a very old letter-list, the Greek, in which alpha and beta were the leading letters. Now all letter-lists are called alphabets. Almost all word lists are organized by letter-lists (alphabets). Looking for "bagels" is not easy in this list:

bundles
beagles
bargains
bugles
bungles

BILL
JOE
FRED
RALPH
IRVING
PETE
GEORGE
MANNY
IGNATZ
MORTIMER
BOB
JACK
DAN

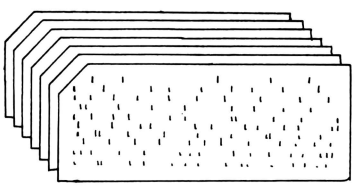
bangles
bagels
barges
boodles

Putting the words in order of their letters makes life easier:

bagels
bangles
bargains
barges
beagles
boodles
bugles
bundles
bungles

The method used here is to arrange them according to the order of the alphabet, starting with the first letter of each word. Because all of our words had the same first letter (they all tied for first), we had to use the second letter. If the second letters are a tie (like bagels, bangles, bargains, and barges), you use the third letter, and so on.

This is simple enough for a human if the list is short. But as the list gets longer, it takes more time to scan and arrange, and the chance of ties in more places gets higher with each new entry.



This list-keeping, by the way, is what started the development of computer technology. The U.S. Census Bureau predicted that by the 1890 census, it would take 12 years to list and tally all of the people in the country, using paper and pencil. The trouble was, they were supposed to do a census every 10 years. The job of developing a computing machine was given to Herman Hollerith, who improved upon the machines used to automate textile mills. The census went on as planned, and to this day, some computer users keep information on Hollerith-type punchcards.

Enough trivia. The program for this adventure will organize lists for you. The list must be kept in a special part of the program, called *data statements.* You can add more data statements as the list gets bigger, but remember that each numbered data line can have no more than 256 items (names, addresses, whatever) and that each element in the list is followed by a comma.

You might want to keep this program handy during holidays, to keep track of gifts. You will also use it a great deal if you need to write a bibliography for school.

Program Listing

```
10  HOME
20  PRINT "            ALPHABETIZE WORDS"
30  PRINT
40  PRINT
50  PRINT "    ENTER THE WORDS TO BE SORTED."
60  PRINT "    PRESS RETURN ONCE AFTER YOU"
70  PRINT "    ENTER EACH WORD.  PRESS RETURN"
80  PRINT "    TWICE AFTER THE LAST WORD ENTERED."
90  PRINT "
100  PRINT
110  DIM W$(100)
120 N = 1
130  INPUT W$(N)
140  IF  LEN (W$(N)) <  > 0 THEN N = N + 1: GOTO 130
150  FOR I = 1 TO N - 1
160 S = 0
170  FOR J = 1 TO N - 1
180  IF W$(J + 1) >  = W$(J) THEN 230
190 V$ = W$(J + 1)
200 W$(J + 1) = W$(J)
210 W$(J) = V$
220 S = 1
230  NEXT J
240  IF S = 0 THEN 260
250  NEXT I
260  PRINT
270  FOR I = 1 TO N
280  PRINT W$(I)
290  NEXT I
300  END
```

Explanation

The variable list and program description are given here.

w$	the words to be sorted
n	the number of each word (first, second, etc.)
i	rank (alphabetical) of each word
j	number of times that comparisons are made between words
s	a toggle counter to keep track of the number of comparisons made
v$	current highest ranking word in list

Lines 10-100. Prints the introduction and instructions.

Lines 110-120. Sets values: DIM means reserve enough space for 100 w$s (100 words); n, the counter for the original order of words equals 1 the first time.

Line 130. Accepts a word and calls it w$ number n.

Line 140. If you typed only a return then it means that your list is done, and the program goes to the ordering routine (line 150); if not, raises the n counter and goes to line 130 again.

Line 150. Starts the loop of words to be compared.

Line 160. Sets the toggle counter (s) to zero (meaning that there are still some words which may have a higher rank than the one being tested).

Line 170. Starts comparing one word to all others.

Line 180. Checks to see if the next word in the list is higher than it. If so, skips all the rest, and uses the next word to compare.

Lines 190-210. If no next word is higher, it stores this word in v$, and moves the next word to be tested into w$(j).

Line 220. Sets the toggle s to 1, which means that there are more words that need to be checked.

Line 230. Sends the loop back to compare the next word(s).

Line 240. If there are no more words to check, sends the program to the display section (line 260).

Line 250. If there are words left to check, sends the loop back to line 150 to continue checking.

Lines 260-300. Prints the words out in alphabetical order.

Sample Run

```
ALPHABETIZE WORDS


ENTER THE WORDS TO BE SORTED.
PRESS RETURN ONCE AFTER YOU
ENTER EACH WORD.  PRESS RETURN
TWICE AFTER THE LAST WORD ENTERED.


?DOG
?APPLE
?ZEBRA
?COMPUTER
?CAT
?BASIC
?LION
?
```

```
ADAM
BASIC
CAT
COMPUTER
DOG
LION
ZEBRA
```

PRETEND DATA

So far, our adventures have brought you through outer space, the atmosphere, into volcanoes and riverbeds, and into your own backyard to collect data. This adventure will test your new-found (or re-awakened) skills in handling data and making conclusions based on that data.

Most people have a mental picture of scientists. Some of these are a little off-base. People often assume that scientists spend their time in dimly lit laboratories, hovering over smelly, mysterious experiments that nobody ever hears about anyway.

That image is partly imagination, and partly the stereotype that

we see in television, films, and cartoons. In reality, a scientist is not unlike a detective. A scientist usually chooses a topic to his or her liking and proceeds to spend his or her life (or a part of it) uncovering new information about that topic. The end product of the vast majority of science is the improvement of life here on earth. This applies

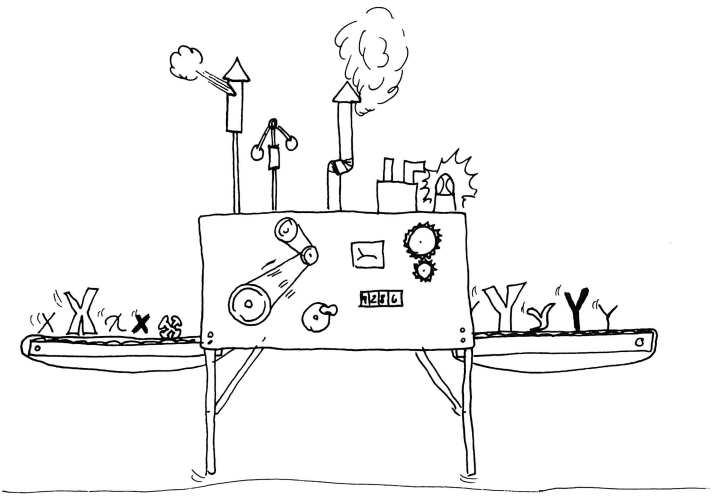
for most of the space program as well as medicine, chemistry, and engineering.

Scientists work to better understand nature and to help us use that understanding to make a better world. The results often depend on the person(s) who ask for the scientists' help. John Kemeny, one of the men who invented the Basic computer language, compares the role of the scientist to the Cheshire cat in *Alice in Wonderland.* When Alice asks, "Would you tell me, please, which way I ought to go

from here?", the cat answers, "That depends a good deal on where you want to get to." Alice says, "I don't much care where—", to which the cat replies, "Then it doesn't matter which way you go."

Scientists, according to Mr. Kemeny, aren't in the business of deciding which direction mankind should be going. But when we decide, they can tell us the best way to get there.

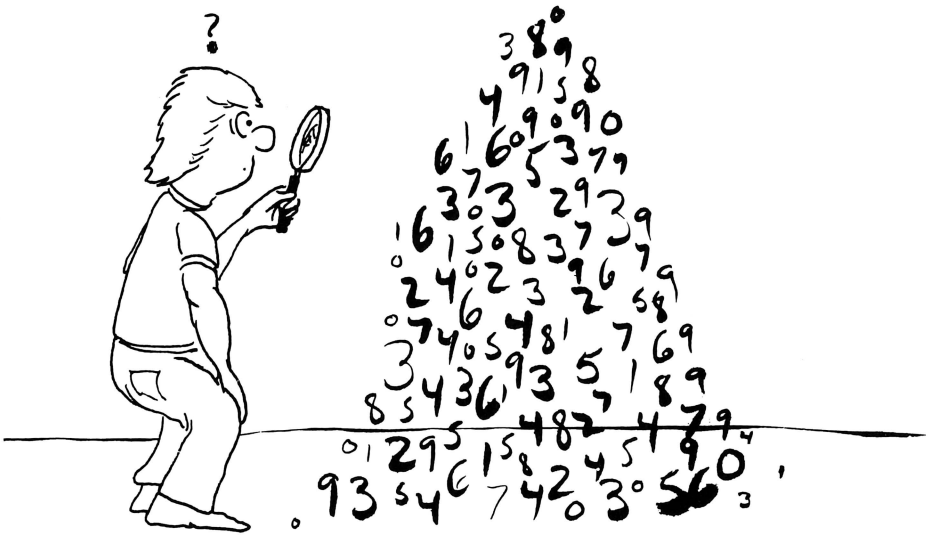
Here's your chance to play detective with some numbers. The program in this adventure will ask you for a number called alpha. It



will take your alpha and turn it into a number called beta. These numbers are related in some way. That is, there is some mathematical operation that the computer does to alpha to get beta. For in-

stance, if your alpha equals two and the beta is seven, the operation could be to add five. The line in the program that sets the rule is line 160. Because you know the rule by typing in the program, this is probably no good to do by yourself. See if you can challenge your friends to change line 160, then run the program for someone who doesn't know the rule.

Good luck and good number-hunting!



Program Listing

```
10  HOME
20  PRINT "    THIS PROGRAM WILL TEST YOUR"
30  PRINT "    DETECTIVE SKILLS WITH NUMBERS."
40  PRINT
50  PRINT "    YOU WILL ENTER 'ALPHAS', AND"
60  PRINT "    THE COMPUTER WILL DO SOMETHING"
70  PRINT "    TO THE ALPHA TO TURN IT INTO"
80  PRINT "    A 'BETA'.  YOUR MISSION:"
90  PRINT "    TO FIND OUT WHAT THE COMPUTER"
100  PRINT "     HAS DONE TO YOUR ALPHA."
110 M =  INT (10 *  RND (1)) + 1
120 I =  INT (10 *  RND (1)) + 1
130  PRINT
140  PRINT "     WHAT IS YOUR VALUE FOR ALPHA?"
150  INPUT A
160 B = M * A + I
170  PRINT "IF ALPHA= ";A;" THEN BETA= ";B
180  PRINT
190  PRINT "     DO YOU NEED ANOTHER CLUE?"
200  INPUT A$
```

```
210  IF A$ = "Y" OR A$ = "YES" THEN 140
220  PRINT
230  PRINT "   O.K., LET'S SEE HOW YOU DID..."
240  PRINT "  YOUR ALPHA WAS MULTIPLIED"
250  PRINT "   BY ";M;" AND THEN ";I;" WAS ADDED TO"
260  PRINT "  IT TO GET THE VALUE FOR BETA."
270  PRINT
280  PRINT "DO YOU WANT TO TRY ANOTHER MISSION?"
290  INPUT A$
300  IF A$ = "Y" OR A$ = "YES" THEN 50
310  END
```

Explanation

The variable list is shown here. The line-by-line description follows it.

m	the multiplier of alpha
i	the addition to alpha
a	alpha (your value)
b	beta (the computer's value)
a$	yes/no answers

Lines 10-100. Prints the introduction and explanation.

Lines 110-120. Chose random numbers from 1 to 10 to use as m and b. (Here's where you can change the program to make it harder. Change the 10s to 100s or 1000s, and it will use bigger numbers.)

Lines 130-150. Asks for your value for alpha.

Lines 160-180. Calculates beta from your alpha and m and b, and displays it for you.

Lines 190-210. Asks if you need another alpha-beta pair.

Lines 220-270. If you need no more pairs, shows you the numbers it used, then asks if you'd like another mission.

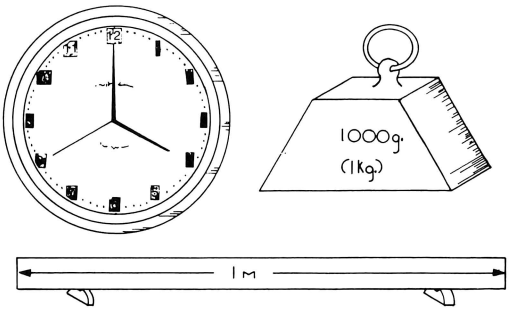
Lines 280-300. Asks if you'd like another mission, and goes back to line 50 to pick new random numbers if you do.

Sample Run

```
THIS PROGRAM WILL TEST YOUR
DETECTIVE SKILLS WITH NUMBERS.

YOU WILL ENTER 'ALPHAS', AND
THE COMPUTER WILL DO SOMETHING
TO THE ALPHA TO TURN IT INTO
A 'BETA'.  YOUR MISSION:
TO FIND OUT WHAT THE COMPUTER
HAS DONE TO YOUR ALPHA.
```

```
   WHAT IS YOUR VALUE FOR ALPHA?
?0
IF ALPHA= 0 THEN BETA= 6

   DO YOU NEED ANOTHER CLUE?
?Y
   WHAT IS YOUR VALUE FOR ALPHA?
?1
IF ALPHA= 1 THEN BETA= 11

   DO YOU NEED ANOTHER CLUE?
?Y
   WHAT IS YOUR VALUE FOR ALPHA?
?2
IF ALPHA= 2 THEN BETA= 16

   DO YOU NEED ANOTHER CLUE?
?N

   O.K., LET'S SEE HOW YOU DID...
  YOUR ALPHA WAS MULTIPLIED
   BY 5 AND THEN 6 WAS ADDED TO
  IT TO GET THE VALUE FOR BETA.

DO YOU WANT TO TRY ANOTHER MISSION?
?N
```

6



Adventures in Physics

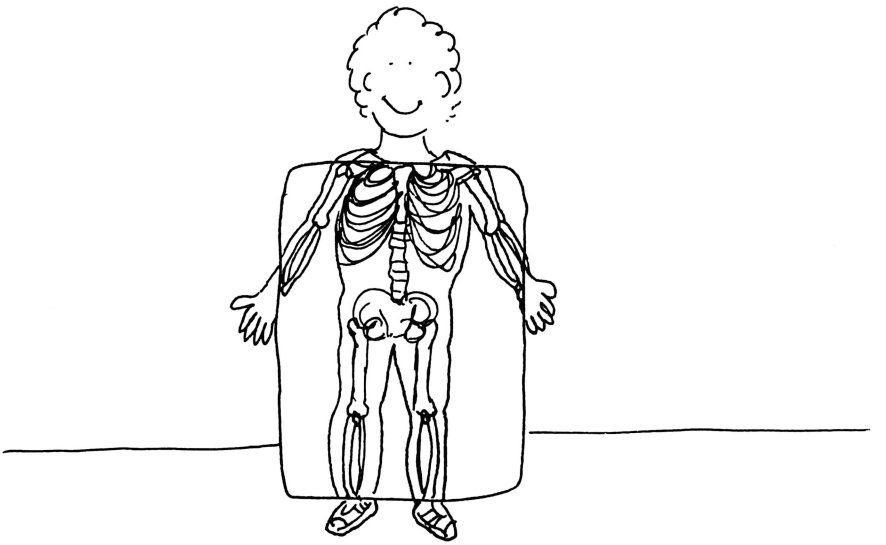
This last (but not least) chapter will take you deeper into science than any of the other chapters. Physics is at the root of all of the sciences. Despite what seems obvious, biology depends on chemistry and chemistry depends on physics. In this chapter you will see some of the fundamentals of physical motion and energy, and we've even thrown in a conversion program to help you both here and elsewhere in converting between systems of measurement. Last stops—all aboard!

FREQUENCY AND WAVELENGTH

All energy in the universe is constantly trying to get somewhere. Some types move quickly, some move slowly, and some are temporarily stalled in the form of mass.

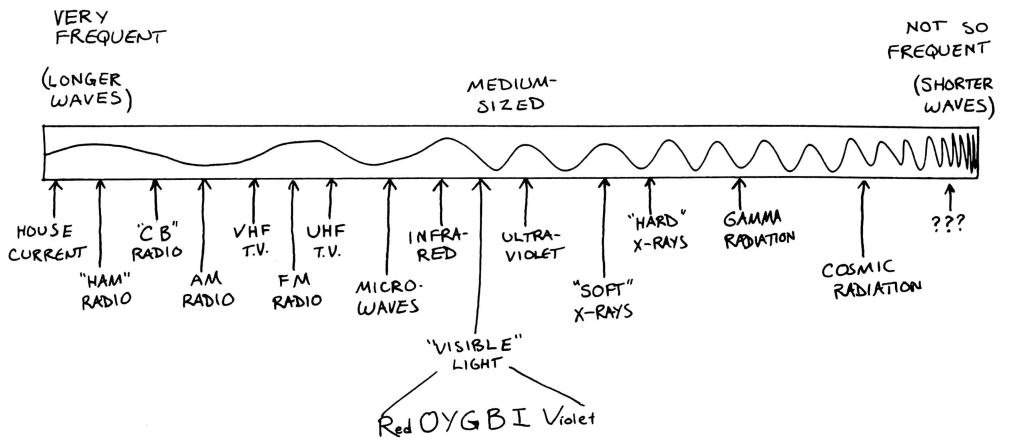
One large group of energies is known as *electromagnetic radiation* (EMR). These energies hold the distinction of being able to travel through empty space, sort of like a car that doesn't need any solid ground.

Needless to say, they are quite strange. The behavior of this type of radiation has puzzled physicists for decades. It turns out that they are very useful. Some of the more popular EMRs include radio waves, television signals, microwaves, infrared, visible light, ultraviolet rays, x-rays, gamma rays, and some cosmic radiation. You've probably come into contact with, or used, most of these. Infrared keeps your hamburgers warm at the restaurant, x-rays allow doctors to examine your insides from the outside. Ultraviolet helps to steril-

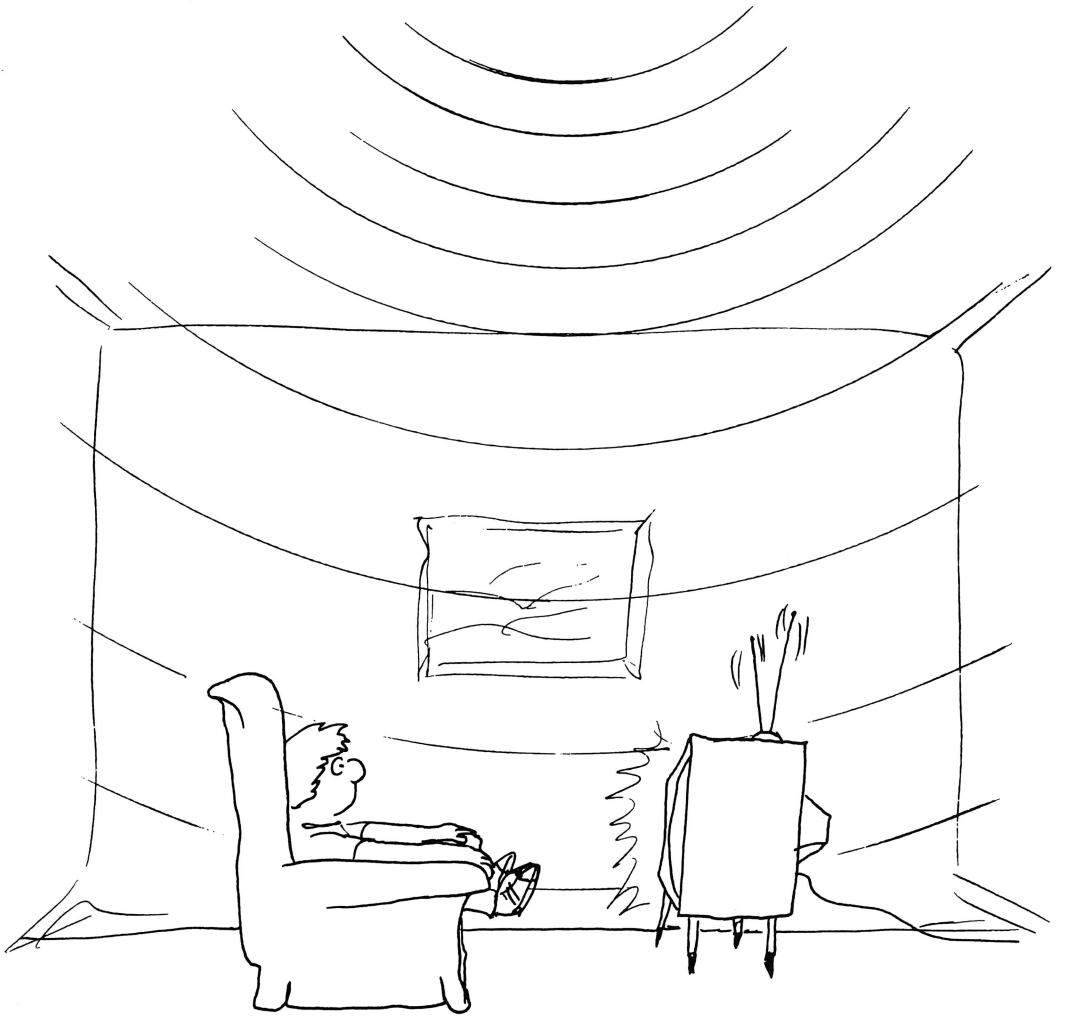


ize hospital equipment, and gamma radiation is a by-product of nuclear power generation.

All of these forms of radiation are closely related. In fact, they are so similar, that they have been known to trade places, and convert from one to the other. This chart shows just how close they are:

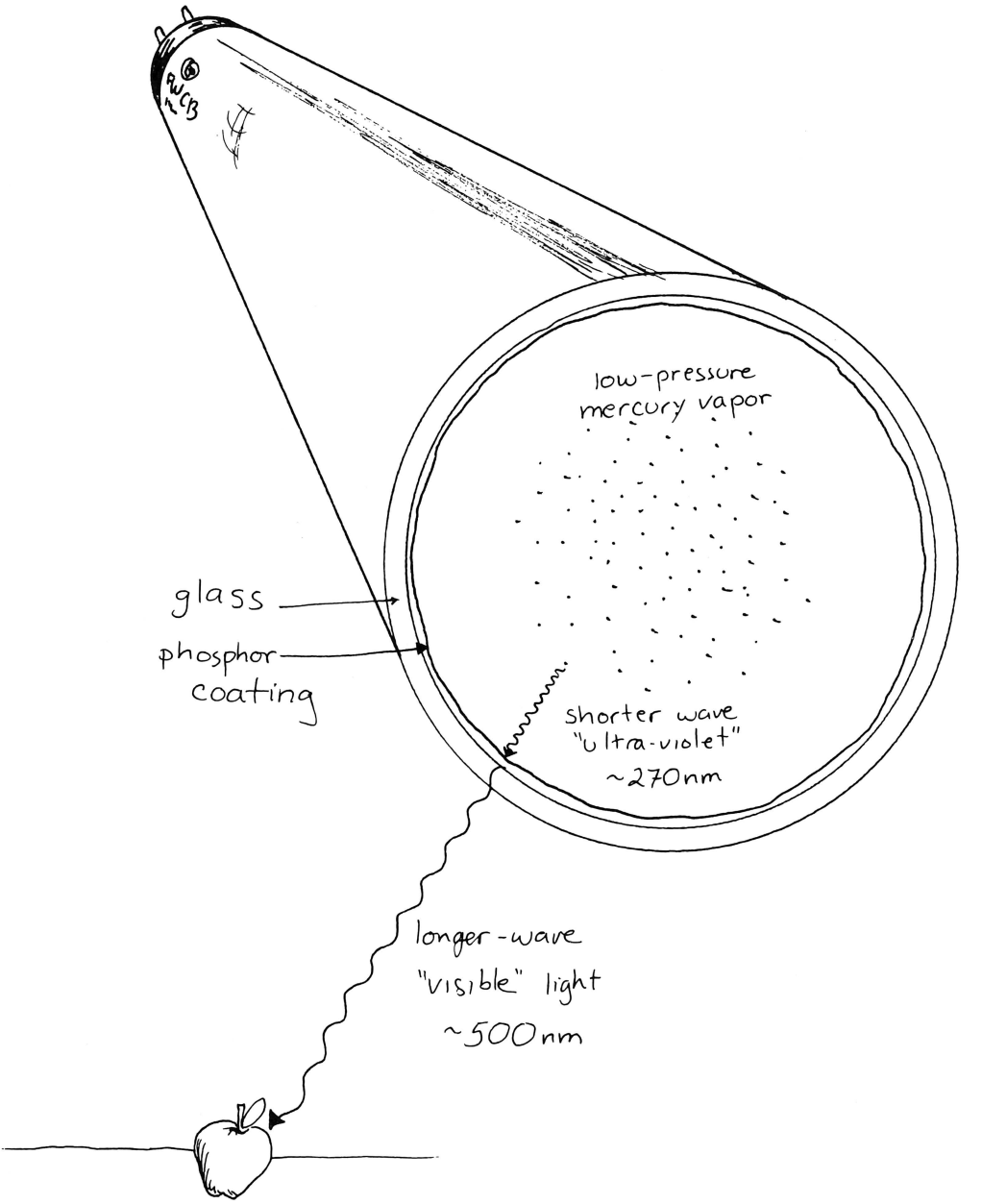


What we call visible light is smack dab in the middle of this spectrum. The reason that we can see this portion of the spectrum is because we have eye pigments that vibrate in harmony (*resonate*) with the waves of light and, in turn, stimulate our brain to think "red" or "green." The other EMRs are invisible to us, being either too long or too short to resonate our pigments. Because they aren't visible, however, doesn't mean that they aren't there. Turn on a radio or



T.V. and you can prove that there's radio waves nearby. The radio towers in your area are putting out more wattage than any light bulb you've ever seen, but your eyes aren't built to pick up those types of waves. And, while x-rays go through you and register on film, that machine in the dentist's office never seems to do much more than click and buzz.

The main difference between these waves is in their length. Like we said, the length can change. For example, the radiation in a fluorescent bulb starts out as ultraviolet, too short for us to see. But when it hits the phosphor coating inside the bulb, it is re-released as longer waves that *are* visible to us. Plants do something similar. They soak up sunlight, which is visible. Any extra sunlight is acted upon by



the green pigments so that it is re-released (*fluoresced*) as "far-red," too long for us to see. Se, green plants actually glow red when they're in the sunlight.

How long or short are the waves that we can see? The limits of our eyes are roughly nothing shorter than 300 billionths of a meter, and nothing longer than 700 billionths of a meter. What does that equal in vibrations? To find out, you need this equation:

Speed of light = Frequency × Wavelength

Thanks to Oleas Romer and Albert Einstein, we know that the speed of light is constant. Thanks to James Bradley and others, we know that the value of this speed is 186,000 miles per second (299,790,000 meters per second). If you have wavelength, just flip this equation around, and you can see that:

Frequency = Speed of light/Wavelength

Our eye's 0.0000003 meter limit turns into 99,990,000,000,000 hertz. (We'll use *hertz* to stand for vibrations per second. Heinrich Hertz was the person who discovered this motion of light waves. The 0.0000007 meter limit equals 42,827,143,000,000 hertz.

If you need to know wavelength, use this formula:

Wavelength = Speed of light/Frequency

An AM radio station at 680 kilohertz (680,000 hertz) has waves that are 440.86 meters long.

To use this program, give the Apple the name of the radiation, and either the frequency or the wavelength, whichever you have.

Program Listing

```
10  HOME
20  PRINT "          FREQUENCY & WAVELENGTH"
30  PRINT
40  PRINT
50  PRINT "   WHICH DO YOU KNOW?"
60  PRINT
70  PRINT "    1.  FREQUENCY"
80  PRINT "    2.  WAVELENGTH"
90  INPUT A
100  ON A GOTO 110,260
110  PRINT
120  PRINT "    NAME THE RADIATION."
130  PRINT "    TYPE (RED LIGHT, ULTRAVIOLET,"
140  PRINT "    TV, X-RAY, ETC.)"
```

```
150   INPUT R$
160   PRINT
170   PRINT "    WHAT IS ";R$;"'S"
180   PRINT "    FREQUENCY IN CYCLES PER SEC"
190   PRINT "    (CALLED HERTZ)?"
200   INPUT F
210 L = 299000000 / F
220   PRINT
230   PRINT "A SINGLE WAVE OF ";R$;" AT "
240   PRINT L;" METERS LONG."
250   GOTO 360
260   PRINT "    NAME THE RADIATION."
270   PRINT "    TYPE (RED LIGHT, ULTRAVIOLET,"
280   PRINT "    TV, X-RAY, ETC.)."
290   INPUT R$
300   PRINT
310   PRINT "WHAT IS ";R$;"'S"
320   PRINT "WAVELENGTH IN METERS?"
330   INPUT L
340 F = 299000000 / L
350   PRINT
360   PRINT "THE FREQUENCY OF A ";L;" METER "
370   PRINT R$;" WAVE IS ";F
380   PRINT " CYCLES PER SEC."
390   END
```

Explanation

The variables list and the explanation of the program are given here.

a	choice of conversions
r$	radiation's name
l	wavelength of r$
f	frequency of r$

Lines 10-40. Prints the title.

Lines 50-100. Asks if you know the frequency or wavelength, and sends you to the proper subroutine. If you answer 1, it goes to 110, if you answer 2 it goes to 260.

Lines 110-150. Asks for the radiation's type (its name).

Lines 160-200. Asks for the frequency of the radiation in hertz (cycles per second).

Line 210. Calculates wavelength according to $c = l * f$ (where $c = 2.99 \times 10^8$ centimeters per second).

Lines 220-240. Displays the result.

Line 250. Goes to the end of the program.

Lines 260-290. Asks for the type (name) of the radiation.

Lines 300-330. Asks for the radiation's wavelength (in

meters: remember, one centimeter is .01 meter, one millimeter is .001 meter, etc.).

Line 340. Calculates frequency based on c = l*f.

Lines 350-380. Displays the result.

Line 390. The end.

Sample Run

```
                FREQUENCY & WAVELENGTH


    WHICH DO YOU KNOW?

    1.  FREQUENCY
    2.  WAVELENGTH
?2
    NAME THE RADIATION.
    TYPE (RED LIGHT, ULTRAVIOLET,
    TV, X-RAY, ETC.).
?ULTRAVIOLET

WHAT IS ULTRAVIOLET'S
WAVELENGTH IN METERS?
?3E-03

THE FREQUENCY OF A 3E-03 METER
ULTRAVIOLET WAVE IS 9.96666666E+10
 CYCLES PER SEC.
```

SPEED OF LIGHT

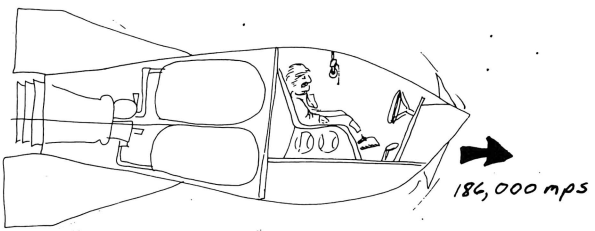
The last adventure showed you the crucial part that the speed of light plays in the use of energy. This time, we'll show you how it affects things that travel very fast — something that caused a revolution in physics and astronomy.

Albert Einstein started his career in science at a very early age. As a child, he was given a compass, whose needle always pointed

north. This puzzled Albert: How could the earth's poles cause the compass to move without touching it?

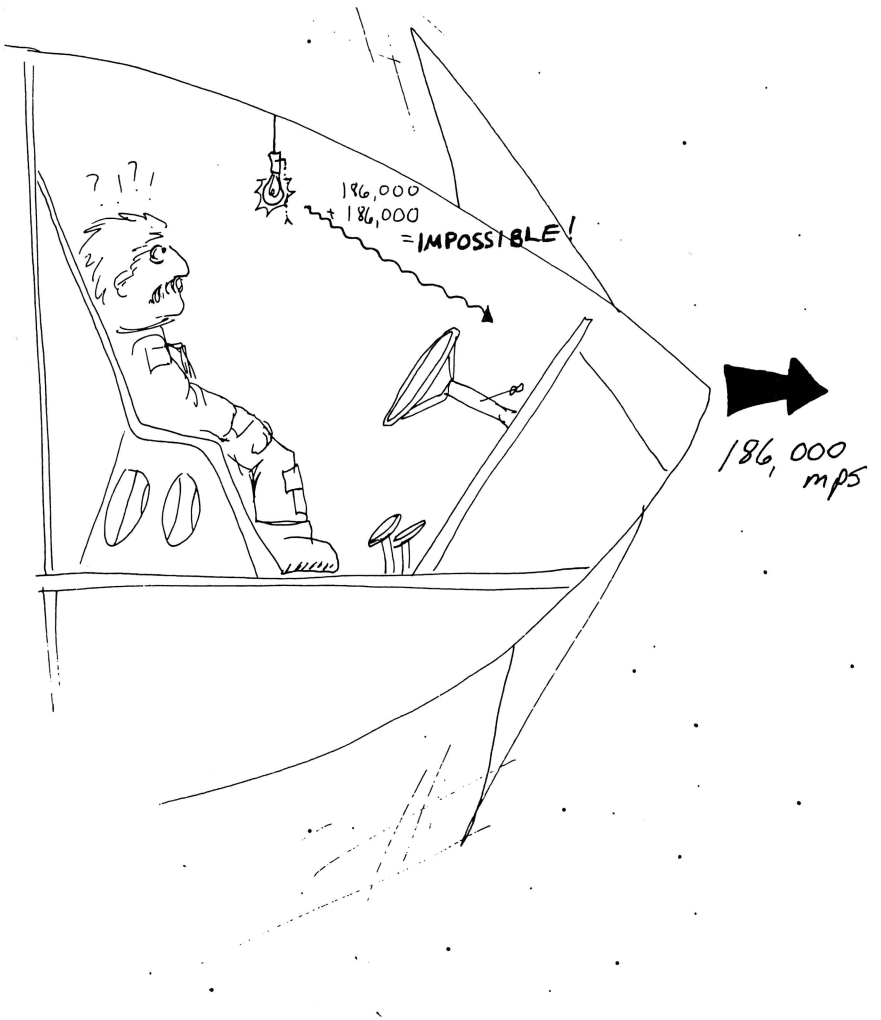
This is what Albert set out to solve. He never figured it out. To this day, nobody has. In that sense, Einstein was a failure. But while digging for the answer, he uncovered secrets of nature more precious than any found before.

Einstein was, by his own admission, a miserable mathematician. He did have the courage to seek out excellent teachers to train him as needed. He also compensated for his lack of math skills with an extraordinary imagination, and a remarkable ability to think through

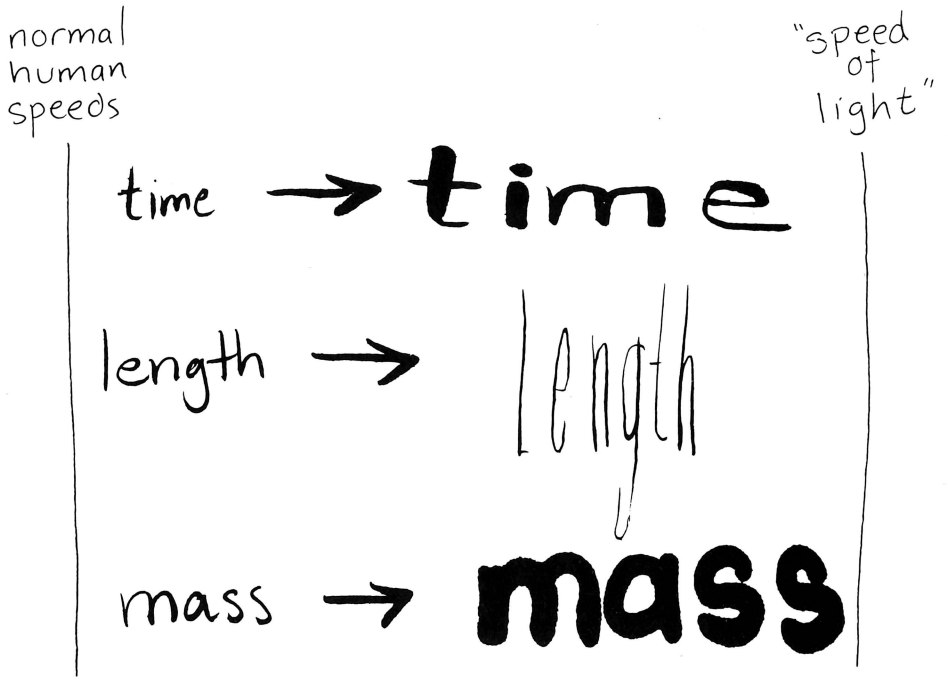


a problem that was difficult to describe in numbers. One of his most challenging thought experiments concerned riding in a spaceship.

Albert knew that the speed of light was the fastest anything could go. If his imaginary rocket sped up until it reached the speed of light, several things would happen. One was that lights on board would stop working (their waves could never go fast enough to hit things at the front of the ship). This was against one of the most important laws of physics, *relativity,* which says that you can't tell what your surroundings are doing unless you go outside of them. The only way that a spaceship could travel near the speed of light is if the ship itself changed length as it sped up, allowing the light inside to keep acting normally. This change is known as the *Lorentz Transformation.* There's another transformation for time, called *dilation,* and a transformation for mass. That's the one that we're going to look at.



Einstein knew that length, time, and mass would all change when an object moved fast enough. The speeds that we humans are used to aren't fast enough to make a big difference (although several

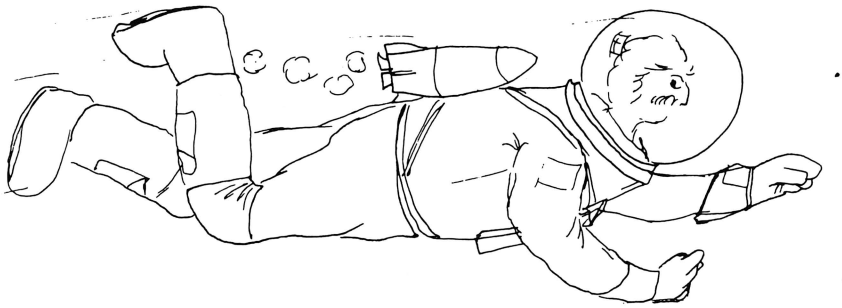


astronauts jokingly put in for .000000001 seconds overtime after a moon mission). He developed equations whose results would only change when the speed was very high, near the speed of light. The one for mass looks like this:

$$m_2 = m_1 \left(\frac{1}{\sqrt{1 - \left(\frac{u}{c}\right)^2}} \right)$$

The expression u/c in the equation is the fraction of the speed of light at which your ship is traveling. Before you miltiply your mass by it, you have to square it, take the inverse of that, take the square root of that, and take the inverse of the square root. Your speed, u, has to be pretty large before it can have any effect.

Rather than use a spaceship, we'll use a simulator. After keying in this adventure's program, run it. The program will start by asking you for your weight, and will calculate your mass in kilograms. You will then see what happens to this mass as you accelerate towards the speed of light. Each time you accelerate, you will increase by one-half of what's left between your speed and the speed of light. You'll never actually reach the speed of light by this method (Why not?). That's alright, though, because one of the other "gems" of physics that



Einstein uncovered was that nothing that is an object can go as fast as the speed of light. Not convinced? The speed controller is in line 190. Try to change it and put in your own values above the speed of light. What happens?

Who knows where your adventures in physics may lead? One of the greatest journeys was started with nothing more than a compass.

Program Listing

```
10  HOME
20  PRINT "    MASS CHANGE NEAR LIGHT SPEED"
30  PRINT
40  PRINT
50  PRINT "    WHAT IS YOUR WEIGHT IN POUNDS?"
60  INPUT W
70 MO = W / 2.205
80  PRINT
90  PRINT "      MPH","    WEIGHT"
100  PRINT "(IN MILLIONS)","(IN POUNDS)"
110  PRINT "--------------------------------"
120 F = .5
130 S = F * .186 * 60 * 60
140 S =  INT (S * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
150 WT = 2.205 * MO /  SQR (1 - F ^ 2)
160 WT =  INT (WT * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
170  PRINT S,WT
180 F = .5 + F / 2
190  IF F < .999999 THEN 130
200  END
```

Explanation

In the following section, the variable list and the program description is given.

w	your weight in pounds
mo	your mass in kilograms
f	fraction of speed of light
s	speed in miles per hour
wt	weight at given speed

Lines 10-40. Prints the introduction.

Lines 50-60. Asks your weight in pounds.

Line 70. Converts weight in pounds to mass in kilograms (2.205 pounds/kilogram).

Lines 80-110. Prints the header for speed/mass chart.

Line 120. Sets fraction of speed of light to ½ for first example.

Line 130. Converts this fraction to miles per hour (times 186,000 divided by 1 million, times seconds per minute, times minutes per hour.

Line 140. Rounds speed to three decimal places.

Line 150. Calculates weight at that speed 2.205 * mo converts to pounds; /SQR(1−f^2) raises f to the second power, subtracts that from 1, takes its square root, then takes its inverse (also known as the Lorentz Transformation for Mass).

Line 160. Rounds to three decimal places.

Line 170. Prints your speed and weight.

Line 180. Raises f by one-half of what's "left" between it and 1.

Lines 190-200. Checks to see if f is too close to 1 (and no more change in weight takes place). If it is, the program ends. If not, it continues at line 130.

Sample Run

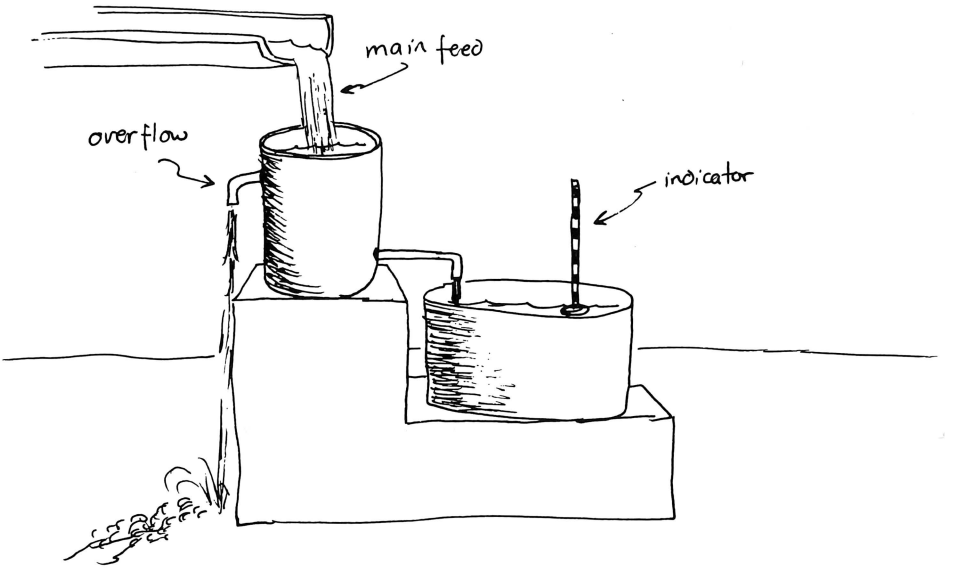
```
   MASS CHANGE NEAR LIGHT SPEED


   WHAT IS YOUR WEIGHT IN POUNDS?
?110

     MPH              WEIGHT
(IN MILLIONS)    (IN POUNDS)
--------------------------------
334.8             127.017
502.2             166.304
585.9             227.215
627.75            316.105
648.675           443.478
659.138           624.699
664.369           881.724
666.984           1245.725
668.292           1760.86
668.946           2489.624
669.273           3520.43
669.437           4978.335
669.518           7040.217
669.559           9956.215
669.58            14080.122
669.59            19912.177
669.595           28160.05
669.597           39824.491
669.599           56321.558
```

PENDULUMS

Clocks are not easy to engineer. The key to a good clock is to find something that keeps doing the same thing reliably, and with very little change in its rate.

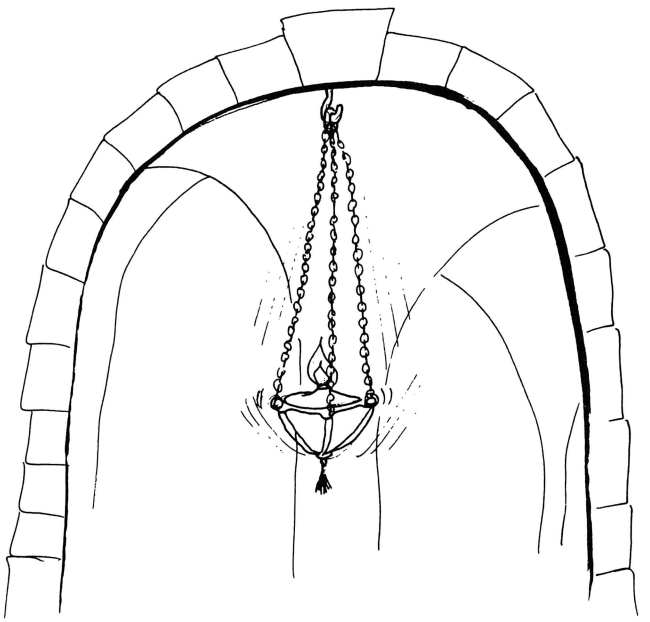
No doubt you've noticed by now the regularity of the sun's apparent motion through the sky. This was one of the first things to be used as a clock, in the invention of the sundial.

Water clocks were soon to follow. Rivers or streams could be channeled into special containers which would constantly drip into an



indicating chamber. As long as there were no heavy rains or long droughts, these *clepsydras* kept good time. They did, however, require plumbing, and could not be transported or used in extreme cold.

One of the first transportable clocks was the pendulum clock. The virtues of the pendulum as a timekeeper were first reported by Galileo Galilei. He noticed a lamp suspended from the ceiling of a

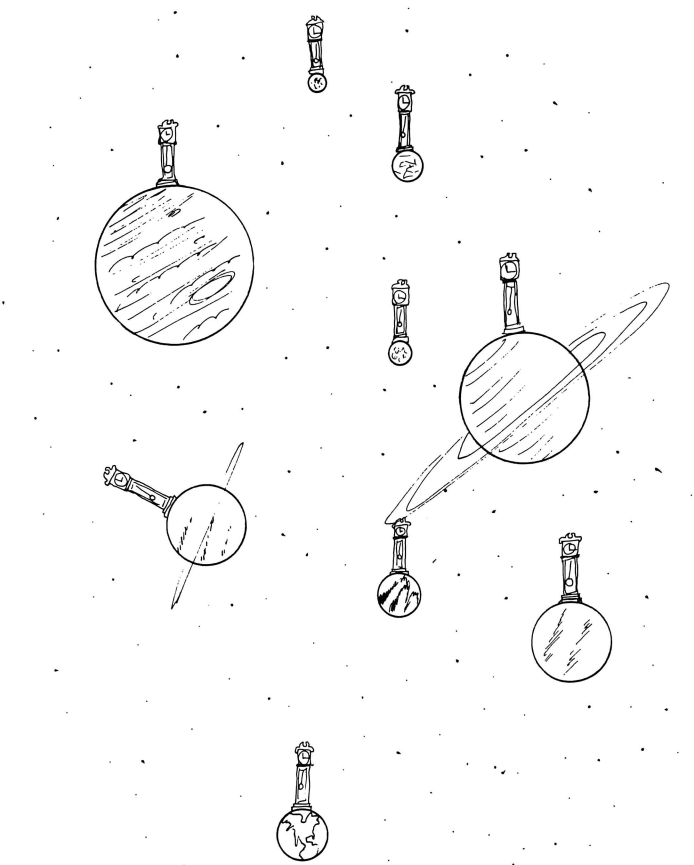


church. The swinging of the lamp was very regular as Galileo timed it with his pulse rate. Galileo then built models of pendulums to find out more about them. He found that four things dictated how fast the pendulum would swing:

- ☐ the length of the string.
- ☐ the mass of the pendulum.
- ☐ the angle of the swing.
- ☐ the local gravity.

If you change any of these things, the period it takes the pendulum to swing will change. And if you choose these things carefully, you can make a pendulum of any period.

This program will tell you the period resulting from any pendulum with the length, mass, angle, and gravity that you specify. With the numbers in the Weights On Different Planets Adventure (page



25), you can write your own new adventure, Pendulums On Different Planets. With a little working backwards, you can choose a period and find out what length, mass, and angle you need.

You might want to build a clock of your own. Pendulum clocks are fairly accurate and are still quite common. The "grandfather" and "regulator" clocks you might have seen are pendulum clocks, and were the mainstay of this country's railroads for many years.

Program Listing

```
10  HOME
20  PRINT "                  PENDULUMS"
30  PRINT
40  PRINT
50 M2 = 5.98E + 24
60 G = 6.67E - 11
70 R = 6378000
80 P1 =  INT ( RND (1) * 30) / 10 + .2
90  PRINT "   YOU MUST MAKE A PENDULUM SWING"
100  PRINT "   WITH A PERIOD OF ";P1;" SECONDS."
110  PRINT "   USE A ROCK TIED TO A STRING"
120  PRINT "   FOR YOUR PENDULUM."
130  PRINT
140  PRINT "   HOW LONG DO YOU MAKE THE"
150  PRINT "   STRING (IN CENTIMETERS)?"
160  INPUT L
170 L = L / 100
180  PRINT
190  PRINT "   WHAT DO YOU CHOOSE FOR THE"
200  PRINT "   MASS OF THE ROCK (IN GRAMS)?"
210  INPUT M1
220  PRINT
230  PRINT "   HOW BIG AN ANGLE DO YOU MOVE"
240  PRINT "   THE ROCK FOR RELEASE (MUST BE"
250  PRINT "   NO MORE THAN 15 DEGREES)."
260  INPUT A
270  IF A > 15 THEN 220
280  PRINT
290  PRINT "   WHAT IS YOUR ALTITUDE ABOVE"
300  PRINT "   SEA LEVEL (IN METERS)?"
310  INPUT Z
320 R = R + Z
330 F = G * M1 * M2 / R ^ 2
340 P = 2 * 3.14 *  SQR (L / F)
350 P =  INT (P * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
360  PRINT
370  PRINT "-------------------------"
380  PRINT "           RESULTS"
390  PRINT "-------------------------"
400  PRINT "   STRING LENGTH:   ";L * 100
```

```
410  PRINT "    MASS:    ";M1
420  PRINT "    ANGLE:   ";A
430  PRINT "    ALTITUDE:    ";Z
440  PRINT "    PERIOD:    ";P
450  IF  ABS (P - P1) / P1 < .02 THEN 500
460  PRINT
470  PRINT "    NOT CLOSE ENOUGH!  TRY AGAIN!"
480  PRINT
490  GOTO 130
500  PRINT "    CLOSE ENOUGH!  GOOD FOR YOU!"
510  END
```

Explanation

The variable list and line-by-line description are shown here.

m2	the mass of the earth
g	universal gravitational constant
r	radius of the earth
p1	random period of swing of a pendulum, picked by the computer
l	your guess for length
m1	mass of the pendulum
a	angle of release for pendulum
z	your altitude above sea level
r	sum of earth diameter and altitude
f	force on the pendulum due to gravity
p	the period of the pendulum that your length, altitude, and mass make

Lines 10-40. Prints the heading.

Lines 50-70. Set values for the mass of the earth, radius of the earth, and gravitational constant.

Line 80. Chooses a random period for the pendulum between 0.2 and 3.2 seconds.

Lines 90-130. Tells you the period that you need to match.

Lines 140-170. Asks you for the string length needed in centimeters, and converts this to meters (1/100).

Lines 180-210. Asks for the mass of the rock needed (in grams).

Lines 220-270. Asks for the angle of release of the pendulum. If this is greater than 15 degrees, it asks again because these formulas only work for small angles.

Lines 280-320. Asks for your altitude-above-sea-level in meters (if you only know feet, there are 3.28 feet per meter), and adds this to the earth radius (the equations need to know how far you are from the earth's center).

Line 330. Calculates the force due to gravity on your pendulum based on the two masses, the gravitational constant, and the radius of the earth (just like in Escape Velocity and Weights On Different Planets).

Lines 340-350. Calculates and rounds-off the period of the pendulum which you chose based on the length and force calculated in lines 330 and 160. 2*3.14 is twice the value for pi, the ratio between a circle's perimeter and diameter. This is used because of the cycle-like motion of the pendulum, and two-pi is the amount of motion you go through in one full cycle of rotation or vibration.

Lines 360-440. Prints your guess and the results.

Line 450. Checks to see if the fraction of error is close enough (less than 1 in 1000). If it is, it goes to line 500. If not, it goes to line 460.

Lines 460-490. Prints the message for large errors, and then re-asks for guesses, starting at line 130.

Lines 500-510. Prints message, and then ends the program.

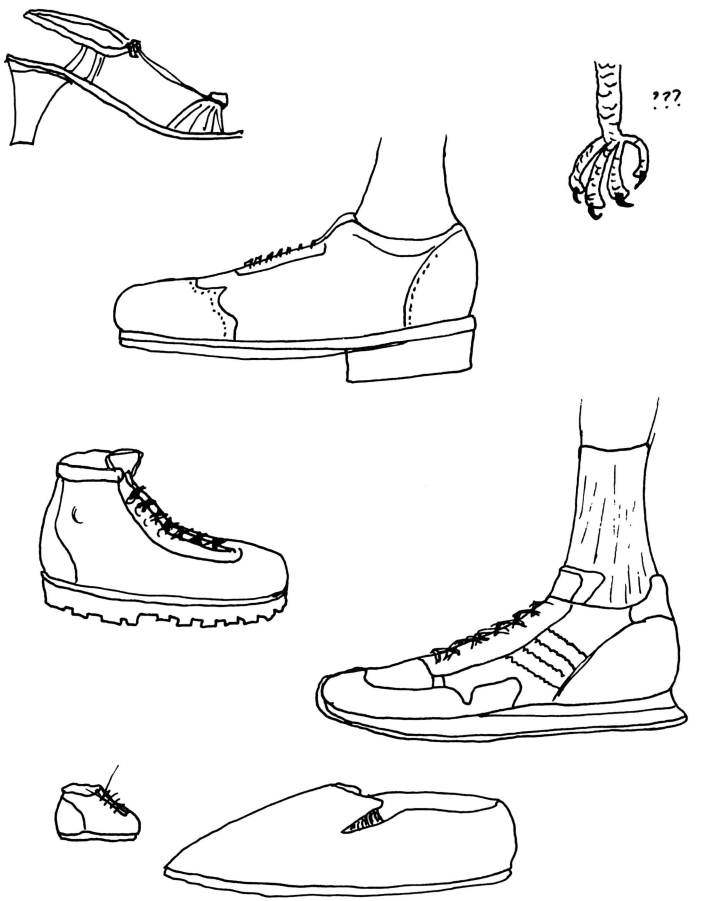
Sample Run

```
                PENDULUMS


   YOU MUST MAKE A PENDULUM SWING
   WITH A PERIOD OF 2.7 SECONDS.
   USE A ROCK TIED TO A STRING
   FOR YOUR PENDULUM.

   HOW LONG DO YOU MAKE THE
   STRING (IN CENTIMETERS)?
?25

   WHAT DO YOU CHOOSE FOR THE
   MASS OF THE ROCK (IN GRAMS)?
?50

   HOW BIG AN ANGLE DO YOU MOVE
   THE ROCK FOR RELEASE (MUST BE
   NO MORE THAN 15 DEGREES).
?10

   WHAT IS YOUR ALTITUDE ABOVE
   SEA LEVEL (IN METERS)?
?100

-------------------------
          RESULTS
-------------------------
```

```
STRING LENGTH:    25
MASS:    50
ANGLE:   10
ALTITUDE:    100
PERIOD:    .142

NOT CLOSE ENOUGH!  TRY AGAIN!


HOW LONG DO YOU MAKE THE
STRING (IN CENTIMETERS)?
?
```

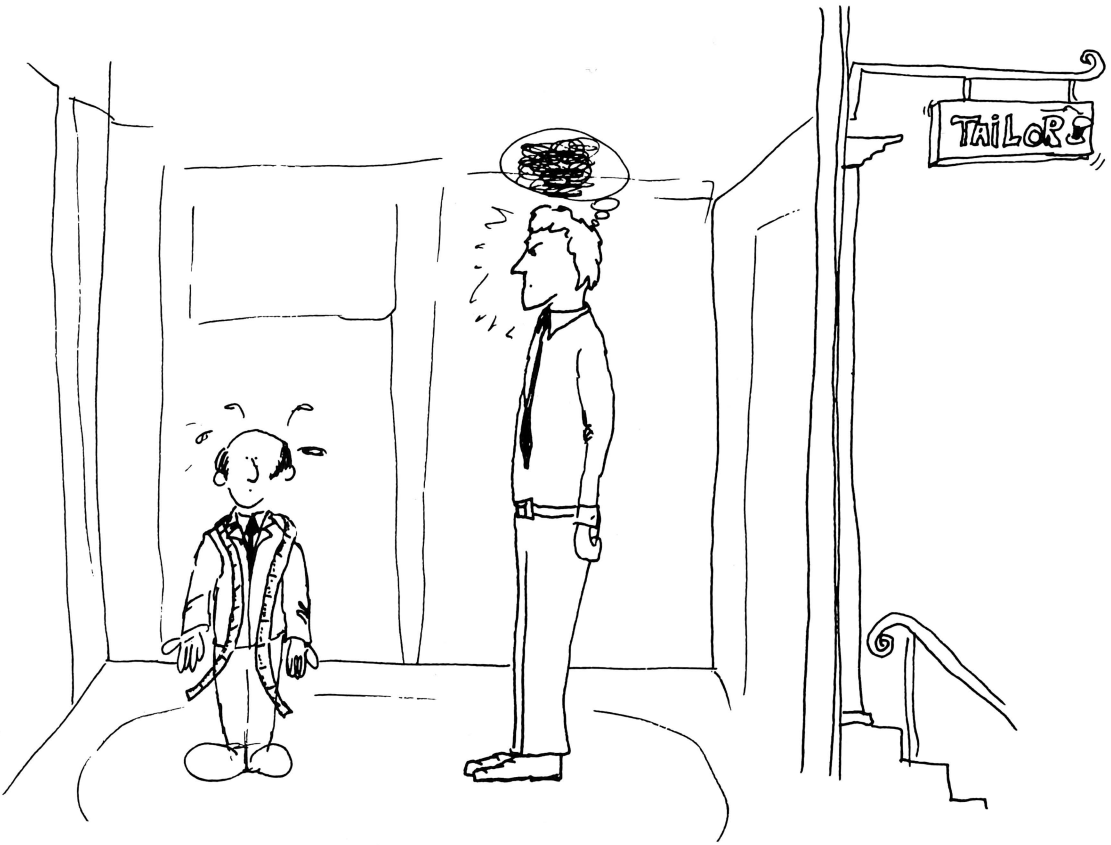
METRIC CONVERSIONS

How long is a foot? Twelve inches is the answer that usually comes to mind. The trouble is, there wasn't always a simple answer to that question. The unit "foot" is just that — the length of a human foot.



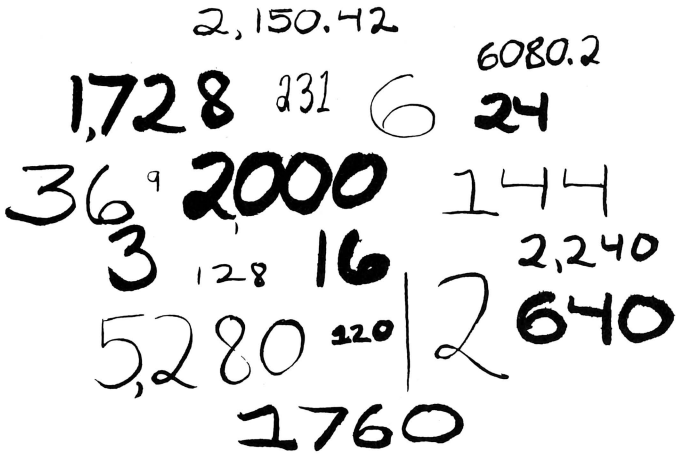
But anyone who has ever bought shoes knows that there are lots of different feet.

Yards were measured in much the same way. A yard was the distance from your nose to your outstretched fingers. This was handy (no pun intended) when measuring cloth or rope, as you pulled it off of a bolt or out of a coil. But what if the seller was half as tall as the buyer? Or if your real estate agent had small feet? Something had to be done about it. A standard had to be used.



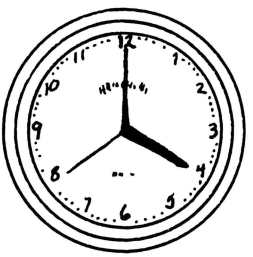
Inches, the law said, were to be as long as three barleycorns laid end-to-end. That worked, because almost all barley has the same size grains. But there weren't objects like that for feet or yards. This is where authority stepped in. England's king decreed that the foot would be the length of his foot, and the yard would be the distance from his nose to his fingertips. Things that kings say usually become very popular, mostly because disagreeing with the king tends to be hazardous to your health. So the English system of measuring started to spread. It became adopted in much of the western world, and solved most of the problems of measurement.

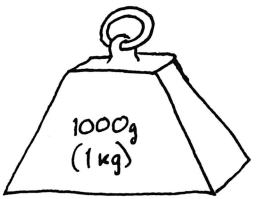
The system itself had one big problem, though. Most of the units were invented independently, with all sorts of conversions between units. The factor between ounces to pounds was 16. Between pounds and tons, the conversion was 2000. Between pints and

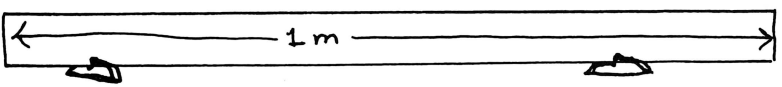


gallons, eight, between feet and inches, 12, and between feet and miles, 5280. Five and one-half yards equaled a rod, and 40 rods equaled a furlong. Four rods made an acre, and 640 acres made one square mile. This hodge-podge of numbers can get maddening!

A new system of measurement was set up. It was decided that there would be only three basic units: seconds (time), grams (mass), and meters (length). Water would be used to standardize the mea-







sures of volume and energy. The meter (from the Latin, "to measure") would be defined first as a fraction of the distance between the north and south poles, later as the length of a platinum-iridium bar,

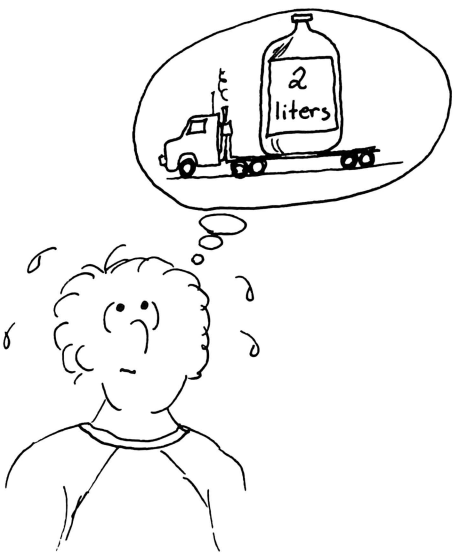
and eventually as a multiple of the wavelength of a vibrating cesium atom (sure beats barleycorns).

Best of all, there would be only one conversion factor: 10! Prefixes would be used to make larger or smaller units:

giga = multiply by 1,000,000,000
mega = multiply by 1,000,000
kilo = multiply by 1,000
centa = multiply by 100
deca = multiply by 10
deci = divide by 10
centi = divide by 100
milli = divied by 1,000
micro = divide by 1,000,000
nano = divide by 1,000,000,000

This seems to go hand-in-hand with base ten, our numbering system, making things easier to convert. It does, but because old habits die hard, the English system still prevails in America today. Oddly enough, the English don't use the English system anymore, they use the metric system. The metric system does get a lot of use in science, because it fits right in with scientific notation.

Most of us, however are used to the English system. Even if you have learned the metric system, you might not have a good "feel" for the physical reality of numbers. We all need to be able to get a mental picture of six kilometers, or a kilogram of sugar, or two liters of soda. Getting those pictures in your mind comes only with experience.



There will be times when you need to produce figures in metrics (like in a lot of these adventures) but all of your information is in English units. That's what this program is for. The Apple will help you convert between systems and allow you to use equations in both systems. It will even quiz you on the systems, if you'd like to test your skills.

Program Listing

```
10  HOME
20  PRINT "      ENGLISH/METRIC CONVERTER"
30  PRINT
40  PRINT
50  PRINT "   THIS PROGRAM WILL CONVERT AN"
60  PRINT "   ENGLISH UNIT OF LENGTH TO A "
70  PRINT "   METRIC UNIT OF LENGTH."
80  PRINT
90  PRINT "   WHAT UNIT OF LENGTH ARE YOU"
100  PRINT "    CONVERTING FROM?"
110  PRINT
120  PRINT "    1.  INCHES"
130  PRINT "    2.  FEET"
140  PRINT "    3.  YARDS"
150  PRINT "    4.  MILES"
160  INPUT UL
170  ON UL GOTO 180,230,280,330
180  PRINT
190  PRINT "    HOW MANY INCHES ARE YOU"
200  PRINT "    CONVERTING?"
210  INPUT I
220  GOTO 370
230  PRINT "    HOW MANY FEET ARE YOU"
240  PRINT "    CONVERTING?"
250  INPUT F
260 I = F * 12
270  GOTO 370
280  PRINT "    HOW MANY YARDS ARE YOU "
290  PRINT "    CONVERTING?"
300  INPUT Y
310 I = Y * 3 * 12
320  GOTO 370
330  PRINT "    HOW MANY MILES ARE YOU"
340  PRINT "    CONVERTING?"
350  INPUT M
360 I = M * 5280 * 12
370 MM = 25.4 * I
380 CM = 2.54 * I
390 DM = .254 * I
400 M = .0254 * I
410 KM = 2.54E - 05 * I
```

```
420   PRINT
430   PRINT "    THAT IS:"
440   PRINT MM;" MILLIMETERS"
450   PRINT CM;" CENTIMETERS"
460   PRINT DM;" DECIMETERS"
470   PRINT M;" METERS
480   PRINT KM;" KILOMETERS"
490   END
```

Explanation

The explanation of the metric length converter program follows:

u1	units being converted from
i	number of inches to convert
f	number of feet to convert
y	number of yards to convert
m	number of miles to convert
mm	converted to millimeters
cm	converted to centimeters
dm	converted to decimeters
m	converted to meters
km	converted to kilometers

Lines 10-80. Prints the introduction.

Lines 90-150. Displays the menu of conversions.

Lines 160-170. Asks for the units, sends the program to the correct subroutines.

Lines 180-220. Asks for the number of inches which you are converting, and then goes to the conversion routine (since your measure is already in inches, jumps in at line 370).

Lines 230-270. Asks for the number of feet which you are converting, converts to inches, and goes to the conversion routine (lines 360-490).

Lines 280-320. Asks for the number of yards which you are converting, converts to inches, and goes to the conversion routine (lines 360-490).

Lines 330-360. Asks for the number of miles which you are converting, converts to inches, and goes on to the conversion routine.

Lines 370-410. Converts the inches in your measure to millimeters, centimeters, meters, and kilometers. (Notice how they only differ by factors of 10.)

Lines 420-490. Displays the converted measure, and ends.

```
      ENGLISH/METRIC CONVERTER


   THIS PROGRAM WILL CONVERT AN
   ENGLISH UNIT OF LENGTH TO A
   METRIC UNIT OF LENGTH.

   WHAT UNIT OF LENGTH ARE YOU
   CONVERTING FROM?

   1.  INCHES
   2.  FEET
   3.  YARDS
   4.  MILES
?1

   HOW MANY INCHES ARE YOU
   CONVERTING?
?2

   THAT IS:
50.8 MILLIMETERS
5.08 CENTIMETERS
.508 DECIMETERS
.0508 METERS
5.08E-05 KILOMETERS
```

Metric Volume Converter Program

```
10   HOME
20   PRINT "      ENGLISH/METRIC CONVERTER"
30   PRINT
40   PRINT
50   PRINT "   THIS PROGRAM WILL CONVERT AN"
60   PRINT "   ENGLISH UNIT OF VOLUME TO A"
70   PRINT "   METRIC UNIT OF VOLUME."
80   PRINT
90   PRINT "   WHAT UNIT OF VOLUME ARE YOU"
100   PRINT "    CONVERTING FROM?"
110   PRINT
120   PRINT "    1.  OUNCES"
130   PRINT "    2.  PINTS"
140   PRINT "    3.  QUARTS"
150   PRINT "    4.  GALLONS"
160   INPUT UV
170   ON UV GOTO 180,230,280,330
180   PRINT
190   PRINT "    HOW MANY OUNCES ARE YOU"
200   PRINT "    CONVERTING?"
```

```
210  INPUT OZ
220  GOTO 370
230  PRINT "    HOW MANY PINTS ARE YOU"
240  PRINT "    CONVERTING?"
250  INPUT P
260 OZ = P * 16
270  GOTO 370
280  PRINT "    HOW MANY QUARTS ARE YOU"
290  PRINT "    CONVERTING?"
300  INPUT Q
310 OZ = Q * 32
320  GOTO 370
330  PRINT "    HOW MANY GALLONS ARE YOU"
340  PRINT "    CONVERTING?"
350  INPUT G
360 OZ = G * 128
370 ML = OZ / .033814
380 ML =  INT (ML * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
390 DL = OZ / 3.3814
400 DL =  INT (DL * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
410 L = OZ / 33.814
420 L =  INT (L * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
430  PRINT
440  PRINT
450  PRINT "    THAT IS:"
460  PRINT ML;" MILLILITERS"
470  PRINT DL;" DECILITERS"
480  PRINT L;" LITERS"
490  END
```

Explanation

The explanation of the metric volume converter follows:

uv	units being converted from
oz	number of ounces to convert
p	number of pints to convert
q	number of quarts to convert
g	number of gallons to convert
ml	converted to milliliters
dl	converted to deciliters
l	converted to liters

Lines 10-80. Prints the introduction.

Lines 90-150. Displays the menu of conversions.

Lines 160-170. Asks for the units, and sends the program to the correct subroutines.

Lines 180-220. Asks for the number of ounces which you are converting, and then goes to the conversion routine (since your measure is already in ounces, jumps in at line 370).

Lines 230-270. Asks for the number of pints which you are converting, converts to ounces, and goes to the conversion routine (lines 360-490).

Lines 280-320. Asks for the number of quarts which you are converting, converts to ounces, and goes to the conversion routine (lines 360-490).

Lines 330-360. Asks for the number of gallons which you are converting, converts to ounces, and goes on to the conversion routine.

Lines 370-410. Converts the ounces in your measure to milliliters, deciliters, and liters. (Notice how they only differ by factors of 10.)

Lines 420-490. Displays the converted measure, and ends.

Sample Run

```
  ENGLISH/METRIC CONVERTER


 THIS PROGRAM WILL CONVERT AN
 ENGLISH UNIT OF VOLUME TO A
 METRIC UNIT OF VOLUME.

 WHAT UNIT OF VOLUME ARE YOU
 CONVERTING FROM?

  1.  OUNCES
  2.  PINTS
  3.  QUARTS
  4.  GALLONS
?1

  HOW MANY OUNCES ARE YOU
  CONVERTING?
?15


  THAT IS:
443.603 MILLILITERS
4.436 DECILITERS
.444 LITERS
```

Metric Weight Converter

```
10  HOME
20  PRINT "      ENGLISH/METRIC CONVERTER"
30  PRINT
40  PRINT
50  PRINT "   THIS PROGRAM WILL CONVERT AN"
```

```
60  PRINT "    ENGLISH UNIT OF WEIGHT TO A "
70  PRINT "    METRIC UNIT OF WEIGHT."
80  PRINT
90  PRINT "    WHAT UNIT OF WEIGHT ARE YOU"
100  PRINT "     CONVERTING FROM?"
110  PRINT
120  PRINT "     1.  OUNCES"
130  PRINT "     2.  POUNDS"
140  PRINT "     3.  TONS"
150  INPUT UW
160  PRINT
170  ON UW GOTO 180,220,270
180  PRINT "     HOW MANY OUNCES ARE YOU"
190  PRINT "     CONVERTING?"
200  INPUT OZ
210  GOTO 310
220  PRINT "     HOW MANY POUNDS ARE YOU"
230  PRINT "     CONVERTING?"
240  INPUT P
250 OZ = P * 16
260  GOTO 310
270  PRINT "     HOW MANY TONS ARE YOU"
280  PRINT "     CONVERTING?"
290  INPUT T
300 OZ = T * 32000
310 G = OZ * 28.35
320 KG = OZ * .02835
330 KG =  INT (KG * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
340 MT = OZ * 3.176E - 05
350 MT =  INT (MT * 10 ^ 3 + .5) /  INT (10 ^ 3 + .5)
360  PRINT
370  PRINT
380  PRINT "     THAT IS:"
390  PRINT G;" GRAMS"
400  PRINT KG;" KILOGRAMS"
410  PRINT MT;" METRIC TONS"
420  END
```

Explanation

The explanation of the metric weight converter follows:

uw	units being converted from
oz	number of ounces to convert
p	number of pounds to convert
t	number of tons to convert
g	converted to grams
kg	converted to kilograms
mt	converted to metric tons

Lines 10-80. Prints the introduction.

Lines 90-140. Displans the menu of conversions.

Lines 150-170. Asks for the units, sends the program to the correct subroutines.

Lines 180-210. Asks for the number of ounces which you are converting, and then goes to the conversion routine (since your measure is already in ounces, jumps in at line 310).

Lines 220-260. Asks for the number of pounds which you are converting, converts to ounces, and goes to the conversion routine (lines 310-420).

Lines 270-300. Asks for the number of tons which you are converting, converts to ounces, and goes to the conversion routine (lines 310-420).

Lines 310-350. Converts the ounces in your measure to grams, kilograms, and metric tons. (Notice how they only differ by factors of 10.)

Lines 360-420. Displays the converted measure, and ends.

Sample Run

```
      ENGLISH/METRIC CONVERTER


   THIS PROGRAM WILL CONVERT AN
   ENGLISH UNIT OF WEIGHT TO A
   METRIC UNIT OF WEIGHT.

   WHAT UNIT OF WEIGHT ARE YOU
   CONVERTING FROM?

   1.  OUNCES
   2.  POUNDS
   3.  TONS
?2

   HOW MANY POUNDS ARE YOU
   CONVERTING?
?55


   THAT IS:
24948 GRAMS
24.948 KILOGRAMS
.028 METRIC TONS
```

Glossary

address — A number that stands for a location in the computer's memory where a piece of information is stored.

air pressure — The force exerted by the weight of the atmosphere from the point of measurement.

assembler — A part of the computer that takes the information inputed and converts it into a form that the computer can understand.

asteroid — A small planet-like body that revolves around the sun. Also known as a planetoid or a minor planet.

asteroid belt — The region between Mars and Jupiter where most of the asteroids in our solar system are found.

astronomy — The study of planets, stars, solar systems, galaxies, and the structure of the universe.

atom — One of the smallest particles of matter.

barometer — An instrument which measures the atmospheric pressure.

Basic — (Beginner's All-purpose Symbolic Instructional Code) A computer language developed at Dartmouth College in 1963. It is a descendant of Fortran, but it is unlike most other languages. It has become the most popular language for personal computers, though, due to its stepwise instruction format.

binary — A system of numbering where there are only two numerals, zero and one. Also known as base two, each digit in a binary number represents a power of two. This is how an electronic computer does its counting, because it can only deal with on or off. The computer translates each character of information into a string of binary numbers.

biology — The scientific study of life and living things.

bit — A binary digit, either a zero or a one. This is the smallest piece of information that a computer can read. These can be put together to make bigger pieces of information. See *byte.*

byte — A collection of bits. Most microcomputers have eight bits per byte. Each byte stands for a character (letter, number, or symbol). Therefore, it generally takes more than one byte to make up a word. For example, it takes eight bytes to make up the word "computer."

chemistry — The scientific study of the properties and changes in matter.

circumference — The length of a circle or the distance around a sphere (great circle).

clepsydra — A water-driven clock.

clinometer — A hand-held instrument used for measuring vertical angles. It is often used for finding the height of tall and/or faraway objects.

coriolis effect — Objects that are in motion on the earth's surface tend to be deflected to the right in the northern hemisphere, and deflected to the left in the southern hemisphere because of the earth's rotation.

cosmic rays — Very high-energy nuclear particles and radiation from outer space.

crystal — A solid in which the atoms are arranged in a repeating pattern. It has an orderly internal structure that is bounded by smooth faces.

deciduous — A name given to trees and shrubs that lose their leaves in the fall.

eclipse — An object casts a shadow on another object, partially or totally blocking the visibility of that object.

electromagnetic energy — The energy associated with electric and magnetic fields.

electromagnetic radiation — (EMR) Electromagnetic waves and electromagnetic energy.

electromagnetic spectrum — Invisible and visible energy waves ranging from very short wavelengths (gamma rays) to very long wavelengths (radio waves) that can travel at 186,282 mps (the speed of light) in a vacuum.

electromagnetic waves — Waves that are produced by a disturbance from an electrical charge. Far from the charge, the waves are made up of electric and magnetic fields that move at the speed of light.

ellipse — An oval shape. Planets move around the sun in an elliptical orbit.

escape velocity — The velocity at which an object can escape, or leave, the gravitational field of a planet.

evergreen — Trees that keep a set of leaves throughout the year.

fluorescent — An object that gives off (emits) light when it is exposed to a form of electromagnetic radiation.

fossil — A cast, track, impression, or body part of an animal or plant that has been preserved in rock.

frequency — The number of vibrations of any given wave or particle in a unit of time.

gamma rays — High energy, high frequency waves that are shorter than x-rays.

geology — The scientific study of the earth, its composition, processes, features, and history.

geometry — The branch of mathematics that deals with the properties and relations of lines, angles, surfaces, and solids.

geosynchronous orbit — An orbit a satellite travels at a particular altitude and velocity in order to stay above a constant point on the earth's surface.

graphics — A display method on a computer screen or paper that produces graphs, charts, diagrams, symbols, and shapes (pictures).

gravitational field — The region in space where an object or particle would experience a gravitational pull. The gravitational pull increases as the mass of the object increses. The gravitational force also increases as the distance between the objects decreases.

gravity — An attraction that occurs between all objects in the universe.

habitat — The place where a living organism lives, and its surroundings.

hexadecimal — Base 16 numbering system. The digits are 0 1 2 3 4 5 6 7 8 9 A B C D E F. Most computers use this in their assembly languages. This is often referred to as hex.

humidity — The measure of the water-vapor content of the air.

igneous — A rock formed by the cooling and solidification of magma.

infrared — Invisible electromagnetic waves that have a longer wavelength than visible light but are shorter than radio waves. They are used to dry and warm things.

mass — The measure of an object's ability to resist force.

matter — Anything that has mass and takes up space.

metamorphic — A rock formed when heat, pressure, and/or chemical action alters a preexisting rock.

meteorologist — A scientist who studies the atmosphere and its phenomena.

microwaves — Invisible electromagnetic waves whose wavelength falls between infrared and radio waves. There are no specific boundaries that distinguish microwaves from infrared and radio waves.

neutron star — A massive star that is in the final stage of its "life cycle." It is made up mostly of neutrons and has a very strong gravitational attraction. This means that very few particles are allowed to escape.

orbit — The oval path traced by a planet, meteorite, or satellite in the presence of a more massive body.

orbital period — The amount of time it takes a satellite to complete one revolution in its orbit.

parallax — The apparent change in position of a faraway object when viewed from different points.

pendulum — A solid object that is suspended vertically from a fixed point and swings freely under the influence of gravity and momentum. It is often used to regulate movement in clocks.

Pioneer — A series of space probes that were launched from earth by the United States. Their mission was to investigate the outer solar system. Pioneer 11 left the solar system in 1983.

protractor — An instrument used for constructing and measuring angles.

radiation — Energy that is given off (emitted) by waves through space or some substance.

relativity — A theory of physics based on the idea that the speed of light is constant. Everything else in the universe (time, length, and mass) depends on the motion of the observer.

resonate — To vibrate in harmony.

rock — A combination of two or more minerals.

satellite — Generally, any small body that orbits a planet or star.

scientific notation — A system that makes the use of very large or very small numbers more convenient.

sedimentary — A type of rock formed by compressing loose sediment, or by precipitation (usually in sea water).

species — Organisms that have many characteristics in common and can breed amongst themselves to produce fertile offspring. For example, a horse and a donkey are different species because their offspring (mule) is not capable of reproducing.

Sputnik — The first artificial satellite launched from earth by the Soviets in 1957. It beeped for 21 days and extended humanity's horizon to space.

Telstar — The first communications satellite to transmit television programs overseas, launched by the United States in 1962. It revolutionized communications between continents.

theory — General explanations based on scientific laws.

time dilation effect — According to the Special Theory of Relativity, the closer a traveler is to the speed of light, the slower time on board the traveler's spaceship would appear to pass to an external observer.

trigonometry — The branch of mathematics that deals with determining the sides and angles of triangles. It is often used in engineering, surveying, navigation, electricity, construction, etc.

ultraviolet radiation — Invisible electromagnetic waves that have wavelengths shorter than visible light. It is often used to kill germs in hospitals and to increase vitamin D content in some foods. Ultraviolet (UV) radiation is present in sunlight, which, when it comes into contact with your body, produces vitamin D in your skin. Too much exposure to UV radiation can be harmful and cause skin cancer.

velocity — Speed in a direction.

visible light — Visible electromagnetic waves whose wavelengths are longer than ultraviolet and shorter than infrared waves. When visible light is passed through a prism, it produces bands of colors.

volume — The amount of space that matter takes up.

Voyager — Space probes launched in 1977 by the United States. Their mission was to investigate the outer solar system. Among the phenomena that the Voyagers discovered were the volcanoes of Io and the icy surface of Europa (two of Jupiter's moons), and the shepherd moons of Saturn's rings.

wave — A rhythmic disturbance which moves through or over space or matter.
wavelength — The length of one wave.
weight — Force due to the effect of gravity.
white dwarf star — A less massive star that is in the final stage of its "life cycle."

x-rays — Electromagnetic waves whose wavelengths are shorter than those of ultraviolet radiation and longer than those of gamma radiation. X-rays were discovered by the German physicist W. K. Roentgen.

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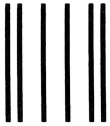

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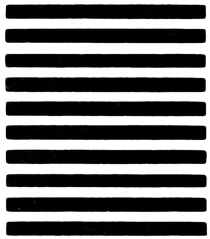

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